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**EXPERT REPORT**

*Of*

**Baker & O'Brien, Inc.**

*In the matter of*

**Civil Number 99-63-DRH**

**United States v. Pharmacia Corporation (f.k.a. Monsanto) et al.**

**for the Sauget CERCLA Area 1, Cahokia, Illinois**

**United States District Court for the Southern District of Illinois**

**East St. Louis Division**

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# **I. INTRODUCTION**

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The Department of Justice for the United States of America (DOJ) has retained Baker & O'Brien, Inc. (Baker & O'Brien) on behalf of the United States Environmental Protection Agency (EPA) to provide expert opinions in the case United States v. Pharmacia Corporation (f.k.a. Monsanto) et al. for the Sauget Comprehensive Environmental Response Compensation and Liability Act of 1980 (CERCLA) Area 1, Cahokia, Illinois, United States District Court for the Southern District of Illinois East St. Louis Division, Civil Number 99-63-DRH.

Baker & O'Brien's opinions address the generation and disposal of wastes at the East St. Louis petroleum refinery formerly operated by Mobil Oil Company (Mobil).

My qualifications are presented in the attached Appendix A. I have not authored any publications within the last ten years. A listing of my expert testimony by deposition or trial within the last four years is attached in Appendix B. For this study, I have been compensated at my normal hourly rate.

I have reviewed published articles, papers, textbooks, and industry publications for the time period of the 1920s through the 1990s. I have reviewed certain source documents and records of Mobil in this matter. I have reviewed certain historical aerial photographs, which were analyzed by others. Also, I have read depositions pertaining to this matter. A complete listing of documents that I reviewed is presented in Appendix C. Finally, I have relied upon my education, training, and experience with and knowledge of (1) refinery operations and maintenance, (2) petroleum (crude oil) refinery equipment and process design, (3) industry standards and practices, (4) physical

properties of hydrocarbons, (5) refinery waste generation and disposal, and (6) the history of the petroleum refining industry.





## II. SUMMARY

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The former refinery located in Sauget, Illinois, known as the Mobil East St. Louis Refinery (Refinery) at the time of shutdown in 1970, operated for approximately 52 years. During this period the refinery produced solid wastes from operations which contained substances designated as hazardous under the CERCLA including benzene, toluene, and xylene (BTX), polynuclear aromatic hydrocarbons (PAHs), phenol and cresols, and heavy metals including chromium, cobalt, lead, molybdenum, nickel, and vanadium. Certain solid wastes, under current EPA regulations, would have been listed as hazardous wastes including slop oil emulsion solids (K-049), heat exchanger bundle cleaning sludge (K-050), American Petroleum Institute (API) separator sludge (K-051), leaded tank bottoms (K-052), crude oil storage tank sediment (K-169), clarified slurry oil storage tank sediment (K-170), spent hydrotreating catalyst (K-171), and spent hydrorefining catalyst (K-172). Some, if not all, of the wastes were disposed outside of the refinery property. An order of magnitude estimate of the volume of wastes from operations for 1918-1970 is 150,000 cubic yards. The estimate does not include non-process related wastes such as paper and packaging materials, construction materials, discarded equipment and piping, concrete and paving, hydrocarbon contaminated soils, laboratory wastes, insulation materials, and paint and solvent wastes. It is highly probable that some part of the estimated wastes were disposed in the burial sites currently described by the EPA as sites G, H, and I.

Over the 52 years of operation, the refinery wastewater discharge most likely contained some free hydrocarbons, hydrocarbon-water emulsions, and hydrocarbon coated solids. The discharge contained BTX, PAHs, and heavy metals.

The discharge flowed into ditches outside the refinery property which drained into Dead Creek until the refinery was connected to the Village of Monsanto (Village) sewer system in 1933. During periods of heavy rainfall, the total flow rate of the combined process water and rainwater would exceed the capacity of the Village sewer system and overflow the refinery API separators. During these excess flow periods, the refinery oil skimming, emulsion skimming, and solids settling equipment would not function efficiently. Higher than normal levels of hydrocarbons, emulsions, and solids would leave the refinery property during these excess flow periods. A portion of this discharge would flow into drainage ditches flowing into Dead Creek.



### III. STUDY METHODOLOGY

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The approach used to evaluate the potential wastes generated at the Refinery during its operating years from 1918 to 1970, is described in the following section. Over the years, an industry publication, the *Oil and Gas Journal*, has published an annual survey of operating refineries and their reported capacities, along with varying levels of detail of the major processes employed at each refinery. These surveys document the Refinery configuration and capacity across its operating history. As each new major refining process was added to the facility, it would appear in the annual survey. This portrait through time of the Refinery capacity and associated process equipment provided the starting point for estimating waste generation.

Several editions of a textbook on petroleum refinery operations were written by W.L. Nelson, who was Professor of Petroleum Refining at the University of Tulsa. These textbooks provide information on refining equipment design, performance, and typical operation for the 1920s through the 1950s. The major pieces of process equipment, which existed at the Refinery, are described in these textbooks. The textbooks also provide insight into waste generation for specific processes and typical waste handling practices for the same periods.

A body of literature from the 1920s through the 1970s is listed in Appendix C, and was reviewed to assess typical refining waste generation, waste management, and waste disposal practices for these years.

Information from the discovery documents and depositions provided specific details about the Refinery. Specific information received included the following: a 1950s plot plan of the Refinery, details on wastewater discharges from 1944 and

1951, aerial photographs, descriptions of the sewer system, flume, and API separators, descriptions of the separator and tank cleaning practices, and the 1961 Mobil authored history of the Refinery. These details allowed Baker & O'Brien to compare the apparent practices at the Refinery to the typical refining industry practices for the same time periods.

We developed an order of magnitude estimate of the Refinery generated solid wastes using the capacities of the Refinery and the specific processes employed at the Refinery within the context of the typical refinery practices for these time periods. Specific solid waste handling practices, as described in the depositions, were used to estimate the most probable method of disposal used for the solid wastes. For the petroleum refining processes and practices where we do not have any specific information about East St. Louis waste handling practices, we used industry typical practices. A summary of the estimated quantity of waste generated is presented in Attachment I.

Non-process related wastes such as construction debris, contaminated soil removal, scrap equipment, insulation, laboratory wastes, office wastes, and sanitary wastes have not been evaluated and are not considered in the estimated waste volumes presented in this report.



## IV. DISCUSSION

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### FUNDAMENTALS OF CRUDE OIL REFINING

A very brief primer about crude oil refining is provided to assist the reader in understanding the waste generation discussions contained in the rest of the report. Crude oil is a mixture of many different hydrocarbons with atmospheric boiling points ranging from -258 degrees Fahrenheit (°F) for methane to approximately >1200°F for the heaviest hydrocarbons. Hydrocarbons are molecules of various combinations of carbon and hydrogen atoms. Most hydrocarbons can be classified as either paraffins (straight chain, single bonds), olefins (straight chain, double bonds), naphthenes (single bonded rings), or aromatics (double bonded rings) depending on the number and structural arrangement of the carbon and hydrogen atoms. Atoms from elements other than carbon and hydrogen can be bonded to a hydrocarbon molecule. The most common bound elements found in crude oils are sulfur, nitrogen, vanadium, nickel, and oxygen.

Most refinery processes can be classified into one of the following types:

1. **Separation** - the physical separation of hydrocarbons according to their boiling point using various methods including distillation and extraction.
2. **Catalysis** - the breaking and joining of hydrocarbon molecules using temperature and pressure in the presence of a catalyst.
3. **Thermal** - the breaking apart of hydrocarbons using high temperature.

The primary products from a crude oil refinery are: liquefied petroleum gas including propane (LPG), gasoline, kerosene, jet fuel, diesel fuel, heavy fuel oil, chemical plant feedstocks, lubricants, wax, asphalt, and coke. Refineries are the manufacturing plants which rearrange the hydrocarbons naturally occurring in crude oils, into the mix of products demanded by the marketplace.

In the late 1800s, the principle product from petroleum refining was lamp oil. Early in the 1900s, the demand for lubricants started to require refineries capable of producing significant amounts of lube oil. By the late 1920s, gasoline and heating oil demand was beginning to grow rapidly. While the depression slowed the growth of gasoline and heating demand in the 1930s, the onset of World War II sparked a rapid increase in petroleum refining capacity and technology to support the war effort. The post war period of the 1950s into the early 1970s saw continued growth of petroleum refining capacity. The oil embargos and recessions of the 1970s slowed petroleum refinery growth. Across the 1970s through present day, the industry has been typified by the steady closure of small and inefficient refineries, and a steady increase of the average size of the remaining operating refineries.

## **REFINERY SITE HISTORY**

The Luberite Refining Company Refinery began operations about 1918. The original lubricating oil plant increased crude input from 650 to 3,500 barrels per day (B/D) from 1918 to 1923. The refinery shifted from lube oil production to fuel products production in 1923 and installed their first cracking stills. Mid-Continent crude oil, typically a light sweet crude oil, was processed. As new oil fields were discovered, Mid-



Continent crude oil encompassed oil production from Southern Illinois, Kansas, Oklahoma, East Texas, and North Louisiana. A crude oil pipeline called the Prairie Pipeline, described as running from the southwest to the Refinery, delivered the Mid-Continent crude oil to St. Louis. Attachment II presents several abbreviated assays of crude oils, which might have been processed at the Refinery.

Luberite Refining Company Refinery became a subsidiary of Vacuum Oil in 1932, and became Socony-Vacuum Oil Company in 1934. The *Oil and Gas Journal* showed that in 1939 the Socony-Vacuum Oil Company Inc. (Luberite) Refinery had increased crude oil distillation capacity to 7,000 B/D and thermal cracking capacity to 4,750 B/D. In the early 1940s, the wartime requirements spurred a significant expansion of the Refinery, increasing the crude oil distillation capacity to 20,000 B/D by 1945. The wartime also saw the construction of equipment to add new refining processes to produce high-octane aviation gasoline. A Houdry fixed catalytic cracking unit and a Thermoform circulating catalytic cracking unit were constructed. The two units were used to convert heavy gas oils into the more valuable fuel products of gasoline and distillates. The combined capacity of the catalytic crackers was 18,000 B/D. A hydrofluoric acid alkylation unit was also added to produce high-octane aviation gasoline with a production capacity of 1,500 B/D. By 1950, the crude oil distillation capacity had risen to 30,000 B/D and a visbreaker with a capacity of 2,700 B/D was added. A visbreaker is a process unit used to reduce the viscosity of the crude oil bottoms by thermal cracking and makes the oil easier to pump, store, and blend into heavy fuel oil.

During the period between 1950 and 1955, crude oil distillation capacity increased to 42,200 B/D. During the same period several process changes were made to the Refinery. The visbreaker was converted into a delayed coking unit to upgrade the crude oil bottoms from asphalt or heavy fuel oil into distillate and lighter fuel products. The coker had a capacity of 9,900 B/D and a coke production rate of 266 tons per day (T/D). Delayed coker coke was essentially solid carbon and was sold into the aluminum smelting industry. A second Thermoform catalytic cracking unit was built increasing catalytic cracking capacity to 29,100 B/D. The new Thermoform unit used airlift while the older Thermoform used a mechanical bucket lift to carry the catalyst beads to the top of the unit. The Houdry cracker was dismantled. A catalytic naphtha reformer, based on the Mobil Sovaformer technology, was constructed to transform 2,750 B/D of low-octane naphtha into a high-octane gasoline component. A catalytic polymer gasoline unit was added to convert light olefinic hydrocarbons into 500 B/D of high-octane gasoline.

The name Socony-Vacuum Oil Company was changed to Socony-Mobil in 1955, and then changed to Mobil Oil Company in 1959. By 1959, crude capacity was 45,000 B/D. The gasoline and distillate producing equipment was expanded, with the Thermoform catalytic cracking units at 30,000 B/D, the delayed coker at 12,700 B/D, the catalytic reformer at 9,670 B/D, the hydrofluoric acid alkylation unit at 2,600 B/D, and the catalytic polymer gasoline unit at 700 B/D. A catalytic naphtha hydrogen treating unit at 16,000 B/D was installed to remove sulfur and other impurities from the naphtha feed for the catalytic reformer.

The refinery did not experience any large capacity changes or addition of processing units between 1960 and its shutdown in 1970. The final published crude

capacity was 50,000 B/D. The Refinery site continued to serve as a products distribution terminal from 1970 until complete closure in 1993.

The history and ultimate fate of the Refinery is consistent with that of many small refineries, which began operation early in the 20<sup>th</sup> century. The period of greatest change and expansion occurred between 1940 and 1955, driven by the demands of World War II and the post war economic prosperity. The post war period saw the tremendous expansion in U.S. gasoline demand and the need for high-octane gasoline to power the high compression engines being manufactured. During the 1970s through the 1990s, many smaller refineries were shutdown by their owners or converted into product distribution terminals. A summary table of the *Oil and Gas Journal* survey results for the Refinery for 1918-1970 can be found in Attachment III. A chart of the major unit capacities for 1918-1970 is in Attachment IV. Estimated Refinery configuration process flow diagrams for 1918-1970 are in Attachment V. A 1950s Refinery plot plan drawing is in Attachment VI.

## **HISTORY OF WASTEWATER DISCHARGE**

The Refinery water discharge from 1918 to 1933 is understood to have flowed off the Refinery property and into Dead Creek. The construction of the Village sewer system in 1933 allowed the refinery wastewater discharge to flow into the Village sewer, which discharged into the Mississippi River. Direct discharge into the Mississippi River continued until 1966, when the Village water treatment plant was put in operation.

A 1944 letter from Socony-Vacuum Refinery to the Village described the reasons for an increase in wastewater discharge from the Refinery and requested an

expansion of the Village sewer system serving the Refinery. The Refinery had a stated normal discharge of 400-700 gallons per minute (gpm), with a maximum of 1,500 gpm, prior to the wartime expansion of the plant. The wastewater discharge consisted of cooling water blowdown, tank testing, tank cleaning, and the washing of process equipment during shutdowns. The addition of the new units increased the normal wastewater discharge to 800-1,000 gpm, with a maximum of 2,500-3,000 gpm.

A 1947 survey of industrial water discharges to the Village sewer system summarized the following findings for the Refinery. The Refinery wastewater discharge was 800 gpm with a pH of 9.0. The Refinery regularly tested their discharge for oil, total solids, total dissolved solids, suspended solids, and pH. All water discharged to the Village sewer system passed through the API separators. Spent phenolic caustic solution was normally not put in the refinery sewer, but was collected in a tank and sold to chemical companies who processed the caustic and removed the phenols. There was no acid sludge produced. One part of the wastewater was 60-90 gpm of process water used for the treatment of gasoline.

A 1951 Illinois water pollution investigation survey reported that the wastewater discharge was 520 gpm (although the well water intake was stated as 660 gpm) and contained 250 parts per million (ppm) of oil and 300 ppm of suspended solids. This equates to approximately five B/D of oil discharged. Approximately 200 B/D of oil was typically recovered from the sewer and separators, treated and reprocessed. This daily volume of oil is indicative of the sewer system being used as an oily waste disposal system. Three primary types of water made up the total discharge. First was 280 gpm of wash water consisting of cooling tower blowdown, wash water from delayed

coker area, and other general purpose wash water. Second was 140 gpm of process water used inside the operating equipment of steam condensate, process wash water, and boiler blowdown. Third was 100 gpm of seal water consisting of pump cooling and pump seal water. Caustic was discharged in the wastewater from two sources. First was caustic from the butene-butane alkylation feed treater at 450 pounds per day of sodium hydroxide. Second was caustic from the boiler blowdown at 75 pounds per day of sodium hydroxide. Free oil in the wastewater typically came from spills to the ground during equipment shutdowns. Efforts were made to minimize spills and recover the oil into refinery tanks for reprocessing.

The recovery of the oil from the Refinery sewer system was described. All the water from the Refinery sewer system first passed through the number four trap where approximately 90 percent (%) of the floating free oil was recovered by skimming the top of the water. The water then left the number four trap and flowed into the flume 90 feet long, 10 feet wide, and 6 feet deep. A skimmer at the end of the flume recovered additional floating free oil. The water leaving the flume then flowed into two parallel API separators approximately 60 feet long, 20 feet wide and 6-8 feet deep. Skimmers at the end of the separators recovered as much of the remaining floating free oil as possible. The separators discharged the water into the Village sewer system. Storm water from the process areas and the north and west storage tank farm areas flowed through the API separators. The east tank area storm water followed the ground contour off of the refinery property. A diagram of the 1951 sewer oil recovery system is in Attachment VII A and B.

A 1963 report for Monsanto on the possible separation of the sewers in the Village stated the average wastewater discharge from the Refinery was 4.5 cubic feet per second, equal to 2,000 gpm. Any storm water flow would be in addition to this rate and would be mixed with the process wastewater since the Refinery did not segregate process wastewater and storm water. A slight rainfall would cause a wastewater discharge of 5,000-6,000 gpm, because of the estimated 65 acres of Refinery land, which drained to the Village sewer.

A 1964 letter from Mobil described storm water run off as backing up in the Village sewer system, flooding the refinery API separators, and overflowing the refinery separator and sewer contents into drainage ditches causing a pollution problem. As was typical for refineries with a single sewer system handling both storm water and process water and oil flows, the large storm water flows acted to flush the Refinery sewer piping of solids and oil, and overload the oil recovery equipment at the flume and API separators. At the Refinery in 1964, this problem was compounded by the inability of the Village sewer system to handle the Refinery water discharge during periods of storm water flow.

The only confirmed treatment of the Refinery wastewater within the Refinery was the use of the API separators to attempt settlement of solids and skimming of free oil and emulsion prior to the wastewater discharge. There is no evidence that dissolved air flotation or chemical neutralization or flocculation was practiced, or that a storm water retention basin existed. A summary of the documented wastewater history is in Attachment VIII.

## **DESCRIPTION OF THE PRIMARY REFINERY ACTIVITIES AND THEIR CONTRIBUTIONS TO WASTE GENERATION**

The Refinery sources of waste can be separated into distinct sections in order to provide an organized description of the wastes, which could have been produced, and the probable disposition of the waste. While the Refinery did expand and change during its history, the various refining activities and process units which were added over time typically would continue to produce their typical waste streams until the Refinery was shutdown in 1970. As the capacity of each of the Refinery process units increased, the waste streams would typically also increase, but the physical and chemical properties of the wastes would remain reasonably consistent. Therefore, each of the following sections will describe a process unit or Refinery section without regard to the capacity of the process across time. A separate section of this report will address the impact of capacity change on the estimated amount of waste generated. A list of the hazardous substances that were probably contained in the Refinery wastes is in Attachment IX.

## **PROCESS CONTACT WATERS**

Process contact water was water which had been in contact with hydrocarbons, and was produced as a waste stream on most of the Refinery process units. Water was condensed from steam which had been used to steam strip or separate hydrocarbons. Wash water was used to remove contaminants in hydrocarbon products. Settled water was drained from the bottom of hydrocarbon tanks. Water was used to flush equipment and to provide hydraulic seals. These waters could become contaminated with BTX, PAHs, and phenols through the physical contact with

hydrocarbons containing these same substances. Process contact water typically would have been drained to the sewer.

## **DRAINING AND CLEANING OF EQUIPMENT**

Refinery processing equipment such as vessels, pumps, and piping would be routinely removed from service in order to perform maintenance repairs and/or modifications. Removing equipment from service so that it could be opened and entered would require that the equipment contents be drained and cleaned. After the equipment contents were emptied to their normal contained disposition, then the equipment would have been water washed and steamed to remove residual hydrocarbons. The resulting steam condensate and wash water would have been drained from the equipment into the sewer system along with the remaining liquid hydrocarbons and any cleaning chemicals. Any accumulated loose solid coke or carbon, scale, salts, and sediments would also go into the sewer system with the drained water. Any remaining materials inside the equipment, such as sludges and solids, would be removed by workers entering the equipment. These wastes would then be disposed. While the draining and cleaning process described above was typical for most of the Refinery process equipment, the quantity and characteristics of the liquids and solids wastes either put into the sewer or disposed as solid waste depended on the service of the specific equipment.



## **HEAT EXCHANGER CLEANING SLUDGE**

Refineries, depending on their size and complexity, would contain several dozen to several hundred heat exchangers. Routine maintenance included internal cleaning of the heat exchanger surfaces. The surfaces would be cleaned by brushing, scraping, and/or high-pressure water blasting. The debris removed would either be disposed or washed into the sewer. The debris removed could contain products of corrosion, sediment, carbon, PAHs, BTX, metals, and heavy hydrocarbons. Prior to 1970, these waste materials were not considered as hazardous wastes, therefore there were no special precautions taken for handling this material.

## **HEATER TUBE CLEANING**

Certain types of crude oil and heavy oil heaters were regularly shutdown and the tubes internally cleaned using a mechanical boring tool. Deposition testimony described this occurring at the Refinery. The debris removed would either be disposed or washed into the sewer. The debris would typically consist of coke particles, metals, and products of corrosion.

## **COOLING TOWER BLOWDOWN**

The circulating cooling water used in heat exchangers to cool hydrocarbons has a small percentage of its volume regularly purged from the cooling water system to control the build-up of dissolved solids created through the evaporative process. This purge was called the blowdown. The blowdown would go into the sewer. Several different circulating cooling water systems could have existed in the Refinery

based on the number of cooling towers shown on the Refinery plot plan developed during the 1950s. When severe contamination of one of the cooling water circulating systems would occur due to leakage of hydrocarbons into the cooling water, much of the hydrocarbon would accumulate in the cooling tower basin. The hydrocarbon would have to be removed from the basin by skimming it off the surface of the water and dumping it into the sewer system. Solids, consisting of air-borne sediment, products of corrosion, and oil coated solids, would accumulate in the bottom of the cooling tower basin. Chromium was used to inhibit water corrosion of equipment, and a portion would settle into the sediment in the cooling tower basin, and ultimately be disposed as part of the sewer and API separator sludges. The turbulence in the cooling water system could also have caused the formation of oil and water emulsions which would have been drained to the sewer system.

## **GENERAL WASHING OF PROCESS AREAS**

The typical practice for maintaining a clean processing area in a refinery was to sweep up solids for disposal and perform general washing using a water hose. The wash water and any spilled hydrocarbons would go into the sewer, along with any solids caught in the wash.

## **LEAKING OF HYDROCARBONS OUTSIDE OF EQUIPMENT**

Spills of hydrocarbons could be handled by flowing the liquid into the sewer system, by being washed up with water and soap or a solvent into the sewer

system, by being absorbed with clay or dirt, or by being shoveled up in the case of the heaviest materials, such as asphalt and coke, and disposed.

## **CRUDE OIL DESALTING**

Crude oil was pumped from the crude oil storage tanks, and the first refining step was to desalt the crude oil. Sodium chloride, along with lower levels of other salts, was removed to minimize the formation of corrosive acids in the crude oil distillation unit heaters and to reduce fouling and plugging of equipment. Desalting produced a waste stream consisting of brine, oil/water emulsion, and some free oil. Typically this stream would go to a tank where free oil was allowed to separate and be recovered, and where heating and chemicals may have been used to break oil/water emulsions. The brine could be drained to the sewer along with some residual crude oil and emulsion.

## **CRUDE OIL DISTILLATION UNIT**

The desalted crude oil would be heated and distilled, or separated into a number of different products, which would undergo further processing in other units. Distillation is the process of separating hydrocarbons by using different boiling points by controlled vaporization and condensation of the hydrocarbons.

## **LUBE OIL PRODUCTION**

The refinery produced lubricating oils from 1918 until 1923. The process for producing the "bright stock" lubricating oils from Mid-Continent crude oil during these

years was distillation followed by contacting the lube oil with high strength sulfuric acid, then with caustic, and then filtration to stabilize the oil, improve its color and odor, lower pour point, and remove wax. A waste stream from this process could have been sulfuric acid sludge containing heavy acid soluble oils and possibly PAHs.

## COKE OVEN UNIT

From 1935 until about 1950, Knowles coke ovens were used to thermally crack petroleum residuum, the heaviest product from the cracking stills. The coke ovens were part of a batch operation that included the regular removal of the coke product from the ovens. The residuum would be heated and allowed to flow into an open pan inside the hot oven. The residuum would thermally crack and generate hydrocarbon vapors which would flow out of the oven to be condensed and captured as valuable liquid products. The portion of the residuum which remained in the pan was coke. When the coking batch was complete, the ends of the oven were opened, and the solid coke slab was pushed out into a holding pit to await loading into trucks or rail cars. The solid coke product was essentially carbon containing some metals (nickel, vanadium, iron) and sulfur. The coke would typically be sold to make electrodes for use in aluminum production, and sold as a solid fuel. Coke fines containing metals and PAHs would be produced by the coke removal and handling, and some portion would be disposed or washed into the sewer.

## **VISBREAKER UNIT**

A visbreaker was constructed in the late 1940s, and was a process similar to thermal cracking, except it processed residuum instead of gas oils. A visbreaker was used to reduce the viscosity of the residuum produced from the crude distillation unit, which allowed more economic blending of the residuum into heavy fuel oil. At the Refinery, the visbreaker was converted into the delayed coker just a couple of years after it was built.

## **DELAYED COKER UNIT**

The delayed coker was a thermal cracking process, which produced liquid products and solid coke from the residuum feed. The Knowles coke ovens were replaced by large steel drums into which was pumped the hot residuum. As with the coke oven, the residuum thermally cracked generating vapors, which were withdrawn from the drum and condensed. The portion of the residuum remaining in the drum was coke and the coke would gradually fill the drum as more residuum was pumped into the drum. The solid coke product was essentially carbon containing some metals (nickel, vanadium, iron) and sulfur. Once the drum was filled with coke, the coke would be cooled with water and then drilled out of the drum using a high-pressure water stream. The coke would fall out of the drum and into trucks or rail cars. The removal of the coke from inside the coke drums and the handling of the coke during rail car loading and transport out of the refinery, generated significant coke fines (small particles) which would be regularly washed off the ground into the sewer and/or swept up and either disposed of as solid waste or added back into the coke product. Typical industry

practice was to wash the coke fines which accumulated on the process area into the sewer using water because the fines were a housekeeping and safety hazard if allowed to accumulate. Rains could also wash coke fines into the sewer. A coking by-product of heavy cracked hydrocarbons called wax tailings were often routed to the sewer. Wax tailings would contain PAHs and phenols.

## **THERMAL CRACKING UNIT**

Thermal cracking units were part of the early refinery as evidenced by the 1924 to 1950 *Oil and Gas Journal* survey data. The refinery used the Fleming and Pratt Vapor Phase thermal crackers. These were batch operated as compared to the continuously operated Houdry and Thermoform Catalytic Cracking Units (TCC). The gas oils were pumped into the cracking vessel, the gas oil was gradually heated, and as the gas oil thermally cracked, the generated vapors were removed from the cracking vessel and condensed into the various products. There was a wide variety of designs of thermal crackers in the industry which performed the same function of producing more valuable light-fuel products from heavy gas oils and residuum. As was typical in industry, the thermal crackers at the Refinery were replaced as the Houdry and TCC catalytic cracking and coking units were developed. The wastes from these units would consist of coke containing metals, and process water, which contacted the hydrocarbon products containing PAHs and phenols generated in the thermal cracking process.

## **THERMOFOR CATALYTIC CRACKING UNITS (TCC)**

The TCC's function was to process gas oils from the crude oil distillation, visbreaking, and coking units, and convert the gas oils into the higher-value products of olefins, gasoline, and diesel. TCCs in many refineries were first built to produce high-octane aviation gasoline for World War II, and after the war were used to produce automotive gasoline. The TCC was an improvement of the fixed-bed catalytic cracking process, such as the Houdry cracker, because it produced a higher yield of the more valuable products. The TCC catalyst was kept circulating in a loop between the reactor side where the gas oil was cracked, and the kiln side where the catalyst was regenerated by burning off the carbon (coke) that accumulated on the catalyst surface. The TCC catalyst consisted of small, hard beads or pellets (three to four millimeters in diameter) made of a composition of silica and alumina. The original TCC design lifted the catalyst using a mechanical bucket elevator, while later designs lifted the catalyst using high-velocity air. Most of the catalyst remained circulating in the recycle loop, while some would escape through one of several paths.

Waste catalyst was produced by several mechanisms. First, was the generation of fines produced by attrition as the catalyst beads circulated inside the TCC. Most of the fines would be captured as dry particles out of the kiln, some would be released into the air in the flue gas from the kiln, and some would end up in the heavy cracked slurry product, also called TCC synthetic crude. The fines would contain an order of magnitude higher metals than the whole bead catalyst. The metals would be mostly vanadium and nickel. Second, a small portion of the whole beads would be regularly removed from the unit and replaced with new catalyst. The used catalyst

would be disposed. Third, leaks in the equipment would spill some catalyst on the ground, which has been described as being picked up and typically disposed. The used catalyst would contain vanadium and nickel and residual carbon.

The heaviest product was the TCC synthetic crude. This product would have been highly aromatic and contained PAHs, and some catalyst beads and fines. The product would be stored in a tank allowing much of the catalyst to settle to the bottom of the tank. The clarified product would be reprocessed in the refinery or sold. The catalyst would be removed as part of the tank-bottom sludge and disposed.

## **B-B TREATER UNIT**

The B-B Treater, seen on the refinery plot plan drawing, was typically used to convert light hydrocarbon di-olefins such as butadiene molecules, into mono-olefins such as butylene. The process utilized was hydrogenation and used a solid catalyst pellet containing a nickel compound, such as nickel sulfide or nickel oxide, impregnated on a clay or silica-alumina base. The catalyst would eventually lose its activity and would be replaced after a few years. The catalyst typically would be disposed of and not reprocessed.

## **HYDROFLUORIC ACID ALKYLATION UNIT**

The alkylation unit produces high-octane gasoline, and was equipment added during World War II to produce high-octane aviation gasoline. Light olefins from the TCC were reacted with isobutane, in a liquid mixture with hydrofluoric acid, to manufacture alkylate, a high-octane gasoline component. The alkylation reaction



combines one light olefin molecule with one isobutane molecule to make one alkylate molecule. The hydrofluoric acid acts as the catalyst to promote the reaction. Typically, 0.3-0.8 pounds of acid were consumed to produce each barrel (Bbl.) of alkylate. An acidic heavy hydrocarbon or tar, referred to as acid soluble oil (ASO), was also produced at a rate of about 6% of the alkylate volume. This ASO oil would have been recovered and either caustic treated to neutralize it and/or burned as boiler fuel. Some residual amount of the ASO could be disposed when it was removed during equipment draining, cleaning, and ASO tank bottoms cleaning. The ASO may also have been occasionally drained to the sewer.

## **NAPHTHA HYDROGEN TREATING UNIT**

The development of the catalytic reforming process in the early 1950s and advances in catalyst technology required the pre-treatment of the naphtha feed to the reformer to remove sulfur compounds and other contaminants which were detrimental to the Sovaformer (reformer) catalyst performance. The Refinery added a naphtha hydrogen treating unit, which processed naphtha from the crude distillation unit, and flowed the naphtha through a catalyst bed while in a hydrogen atmosphere. This process removed the sulfur from the naphtha. The catalyst would eventually lose its activity and would be replaced after a few years. The catalyst typically would be disposed of and not reprocessed. The hydrogen treating catalysts were typically composed of pellets with cobalt or nickel and molybdenum impregnated on a base of bauxite or fuller's earth.

## SOVAFORMER CATALYTIC REFORMING UNIT

The Sovaformer was the Socony-Vacuum and Mobil trade name for their catalytic reforming technology to produce high-octane gasoline from light naphthas. The reforming process consists of a number of different reactions, which result in increasing the octane of the naphtha, producing BTX aromatics and hydrogen gas. The Sovaformer process utilized a solid catalyst described in literature as 0.5% platinum impregnated on an aluminum oxide base. The fixed-bed catalyst would have to be regularly regenerated in place by heating with air to burn off accumulated carbon deposits. Eventually, the catalyst would no longer be able to be regenerated in place, and would have to be removed from the equipment and replaced with fresh catalyst. The spent catalyst, being valuable since it contained precious metal platinum, would be recovered in containers upon removal from the equipment, and then transported outside the refinery to a catalyst reprocessing facility. Typically, very little if any of the catalyst would be allowed to be disposed as solid waste or allowed to go into the sewer system.

## POLYMER GASOLINE UNIT

The polymer gasoline unit produced high-octane gasoline from pentene and hexene olefins produced by the TCC. The polymer reaction is to combine two olefin molecules to create one polymer gasoline molecule. The process typically utilized a fixed-bed solid catalyst, which was impregnated with phosphoric acid. The active catalyst was supported on a bed of fine-mesh quartz. Once the catalyst became inactive, phosphoric acid would be introduced into the catalyst bed to renew the catalyst. Eventually, the solid catalyst would no longer be able to be renewed with

phosphoric acid, and would be removed from the equipment. This catalyst was relatively inexpensive and would be disposed of as a solid waste rather than recycled. The solid waste would consist of the aluminum oxide catalyst base with residual phosphoric acid contained in the catalyst, and the quartz support media.

## **DOCTOR SWEET GASOLINE TREATING UNIT**

One of early gasoline treating processes was contacting gasoline with a either a solution of alkaline lead oxide or a solid catalyst containing lead sulfide, as a way to eliminate foul smelling mercaptans from the gasoline. The process required the regular addition of elemental sulfur. Deposition testimony described the regular dumping of bags of elemental sulfur into a gasoline treating unit. This would have been a doctor sweet treating unit. Waste from this unit was the occasional release of lead sulfide contained in solution or in solid catalyst.

## **SOLUTIZER GASOLINE TREATING UNIT**

An advancement in gasoline treating was the Solutizer treater. Gasoline was treated to remove mercaptans and hydrogen sulfide by the Solutizer process. The gasoline was washed with a caustic solution, which also contained a solubility promoter such as salts of isobutyric acid or alkyl phenol. The caustic solution was regenerated and reused within the unit, with a small percentage of the solution purged to control the solution quality. The purge would typically go to the sewer. The process has also been described as being "caustic tannin," which is a process similar to the Solutizer with the solution being regenerated by air instead of steam.

## **KEROSENE TREATING UNIT**

The demand for low-odor kerosene was addressed by the treatment of kerosene with a caustic soda solution. The caustic soda removed mercaptans, which are foul smelling sulfur compounds, and certain other objectionable sulfur compounds. This process was known as "sweetening." Kerosene, which was produced from low-sulfur or sweet crude oils, would typically only require a caustic soda wash. Kerosene produced from high-sulfur, or sour crude oils, could often require a sulfuric acid wash followed by a caustic soda wash to remove the higher levels of objectionable sulfur compounds.

The waste stream from kerosene treating would be a weak sulfidic caustic soda solution.

## **ACID TREATING OF GASOLINE AND KEROSENE**

Typical petroleum refining practice, prior to widespread acceptance of catalytic hydrotreating, was to treat the gasoline and kerosene produced from sour crude oil using sulfuric acid to reduce the sulfur levels in the products. Acid treating produced a waste called acid sludge, which was one of the more difficult waste streams to dispose. The 1951 Illinois water pollution inspection report stated that the Refinery did not perform acid treating at that time because they only processed sweet crude oil, and therefore did not produce acid sludge. Deposition testimony states that the Refinery, sometime after 1951, did occasionally process sour crude oil. In 1961, the crude charge was described as 97% sweet Mid-Continent and 3% Wyoming Sour crude. No confirmation has been found to date whether an acid treating unit existed at

the Refinery. The *Oil and Gas Journal* annual capacity surveys do not capture the level of detail to know which refineries had acid treating units. Sour crude oil was available to the refinery through the same pipelines that delivered the sweet crude oil.

Industry recommended disposal of acid sludges was by treatment to separate the acid and hydrocarbon, with the hydrocarbon burned either as fuel in refinery heaters or burned just for elimination. Certain light acid sludges with lower-acid levels were burned without undergoing a separation treatment.

## **PRODUCT FILTERS**

It was industry practice to filter kerosene and sometimes gasoline products through filters containing media such as clay or Fuller's earth. After a period of time, the clay would become saturated with contaminants and would be replaced. Some refineries built kilns to regenerate the used clay to reduce the cost of purchasing new clay. Eventually, the clay would be disposed by burial, and depending on what washing or steaming was done to the clay, it could still contain BTX and PAHs. It is not known if treating clay regeneration kilns existed at the Refinery.

## **TETRA ETHYL LEAD**

The primary additive to boost the octane of gasoline was tetra ethyl lead (TEL). Lead addition began in response to the demand for higher-octane gasoline. TEL was typically stored as a liquid in steel tanks in a building located in the gasoline storage tank area. The TEL would be added in small amounts to the gasoline tanks. Mixers inside the tank would ensure the TEL was well dispersed in the gasoline. The

leaded gasoline tank bottoms would contain TEL. TEL remained in use by the petroleum refining industry through 1970 when the Refinery shutdown. The TEL manufacturers' recommended disposal practice for leaded gasoline tank bottoms was burial including burial near the tank.

## CRUDE OIL STORAGE TANKS

Crude oil was received into the Refinery from pipelines, and possibly by rail car and trucks, and stored in large cylindrical tanks until being processed. The crude oil would contain a low-level of inorganic basic sediment and water (BS&W), typically less than a combined 1% by volume. A portion of the BS&W would settle out of the crude and drop to the bottom of the tank. Periodically, the water would be drained off the bottom of the tank. This water was likely drained onto the ground outside the tank or to the sewer. Trace amounts of oil and sediment would flow with the water, and potentially straight crude oil, if the water drain was allowed to continue too long. Emulsions of oil and water could also have been drained. Eventually, each crude oil tank would be emptied and entered for cleaning and inspection. The time interval between cleanings depended on the rate of bottoms build-up and mechanical integrity of the tank. Intervals of between five to twenty years were common. Along with the settled inorganic sediment, some heavy hydrocarbons in the crude oil could also settle out to the bottom of the tank, creating a crude tank-bottom sludge. Typical cleaning procedure to remove the sludge would be to add a lighter hydrocarbon into the drained tank to assist in dissolving part of the sludge and then pumping out as much of the material as possible to contained storage. The removed liquid could be reprocessed in

the refinery. The remaining sludge would then be washed out or shoveled out of the tank. Possible disposal of the sludge included washing into the sewer with large amounts of water, dumping on the ground around the tank, dumping into a pit or pond on the refinery property, or burial at an off-site dump. The crude tank bottoms could contain sediments, salts, metals, sulfur compounds, and heavy hydrocarbons including PAHs.

## **GASOLINE, KEROSENE, AND DIESEL STORAGE TANKS**

The gasoline, kerosene, and diesel storage tanks would have collected water at the bottom of the tanks, which would have been drained to the ground or to the sewer on an infrequent basis. The tanks would be emptied and entered once every five to twenty years to have any debris at the bottom of the tank removed. The debris would consist of sediment, products of corrosion, and sludges formed from the degradation of the hydrocarbon. Both the gasoline and distillate would contain a high-percentage of thermal and catalytic cracked unsaturated hydrocarbons, which are prone to polymerize and form higher molecular weight hydrocarbon sludges. Gasoline sludge would contain BTX and TEL. Diesel sludge would typically contain PAHs and phenols. The debris would be removed by workers and disposed of as waste, either left on the ground around the tank, disposed inside the refinery, or hauled out of the refinery and disposed.

## **HEAVY FUEL OIL STORAGE TANKS**

Since the refinery had coke ovens and then a delayed coker for most of its operating history, the production of heavy fuel oil would likely be infrequent and of a

smaller volume relative to the other products. Tank bottoms from the fuel oil tanks could contain heavy, waxy hydrocarbons, PAHs, vanadium, nickel, and perhaps lead coming from the recovered slop oil.

## **HEAVY FUEL OIL BOILERS**

Steam boilers which burned heavy fuel oil or the synthetic crude (TCC bottoms) would produce fly ash. Fly ash was the non-combustible residue of the combustion of the fuel, and would have contained some heavy metals such as vanadium, nickel, and iron.

## **SEWER CATCH BASIN, SUMP, AND API SEPARATORS**

Many sewer systems in refineries were constructed to handle water and hydrocarbons similar to the Refinery. Typical surface drains into the sewer system would consist of a catch basin and a seal. The catch basin served as the first solids collection point in the sewer system. The draining water would flow down into the catch basin, flow under a baffle, and then flow over a second baffle. The baffles served two purposes: 1) facilitated the settling of the heaviest solids in the catch basin between the baffles, and 2) maintained a water seal in the catch basin so that sewer gases would not be released and to minimize oxygen ingress into the sewer to reduce the risk of explosion.

Sewer catch basins were cleaned on a regular basis to remove accumulated solids. The API spoke of the need to regularly clean refinery catch basins as early as 1933, and the need to dispose of the removed material. The material



removed from the catch basins would typically consist of solids (dirt, coke/carbon, spent catalyst, general debris) coated with hydrocarbons. As solids flowed into a catch basin, they would pass through the hydrocarbon layer on top of the water and become coated. Once coated, the solid would typically remain coated even with the continued flow of water through the catch basin. If the catch basin was not cleaned out, the flow rate through the catch basin could be restricted, and/or would reach a point where any additional solids put into the catch basin would not settle out, but would be carried over into the downstream sewer piping. Based on deposition, testimony, and typical refinery sewer design and industry practice, it is reasonable to conclude that the Refinery had catch basins on their sewer drains. They would have had to be regularly cleaned out to remain effective.

The 1951 State of Illinois water pollution investigation report stated that all sewer flow was directed into the #4 trap where free oil could be skimmed off the top of the water. From there, the sewer flow entered a flume. The purpose of the flume was to provide an area for the sewer flow to become less turbulent and to reduce flow speed so that free hydrocarbons had time to float to the top of the water and some solids to settle. A skimmer at the end of the flume collected as much free oil as it could.

After the flume, the sewer flows into two parallel API separators. Aerial photographs show both separators in existence in 1950, and appear to show at least one of the separators and the flume in existence in 1940. The actual date of construction of the separators and flume is not known. At the end of each separator was a final skimmer to capture whatever remaining free oil it could. The plot plan of the Refinery, drawn sometime during the 1950s, showed a series of slop oil recovery tanks

located next to the separators. Most likely, these tanks were used to collect the skimmed oil recovered from the separators and flume, to separate the oil and water by allowing extended settling time, and to provide a tank to possibly add heat and/or chemicals to help break emulsions. The recovered clean oil would then be pumped back to be reprocessed in the refinery.

Just as with the catch basin, the API separators would need to be drained and cleaned of collected solids on a regular basis. Failure to do so would result in increased solids being carried out of the separator, into the Village sewer system and eventually into the Mississippi River. Prior to the construction of the Village sewer system in 1933, these solids could have flowed into Dead Creek.

One deposition described the cleaning of a separator sometime during the 1950-1970 period. The process described was that operations would stop the flow into one separator and would pump the water over into the operating separator. They continued to pump over into the other separator as long as they physically could. Once the remaining material could no longer be pumped, the sludge was removed by workers into disposal bins. This material would be a mixture of a variety of solids, coated with hydrocarbons and wet with water. The sludge could contain BTX, PAHs, phenols, and metals including lead, vanadium, nickel, and chromium.

There has been no evidence of on-site disposal of the separator and sewer sludge on refinery property. Deposition testimony states that they did not dispose these sludges onsite.

## **OIL AND WATER EMULSIONS**

One of the most troublesome liquids in the sewer system was emulsions. There were two types of emulsions. The first would be an oil in water emulsion found between the separate oil and water phases. The second would be water in oil emulsion found near the bottom between the separate oil and solids layer. Oil in water emulsions was the most common in refineries and the more difficult of the two types to separate. Typical emulsions could not be broken into free water and oil within the sewer and separator system. Auxiliary treatment methods such as mixing with acid, salts, and heating in separate tanks were required. Wastewater with an alkaline pH, as existed at East St. Louis, is more prone to generate stable oil-water emulsions.

## **OPERATION OF SITE AS A PRODUCTS TERMINAL 1970 – 1993**

The terminal received hydrocarbon product from other locations. A product terminal handling gasolines #1 and #2 diesel would typically generate wastes consisting of settled tank water and tank bottom sludge from the product tanks similar to refinery product tanks. The water draws and bottom sludge could contain BTX and lead from the gasoline, PAHs and phenols from the diesel. As lead phase-out began in the 1970s, the lead in the gasoline would have gradually declined to negligible levels by the early 1990s.

## **REVIEW OF HISTORICAL AERIAL PHOTOGRAPHS**

An analysis of historical aerial photographs of the refinery site was performed by Environmental Research Incorporated (ERI). Baker & O'Brien reviewed a

selection of photographs provided and annotated by ERI, for the years 1940 through 1978 and reached the following observations.

No significant disposal areas such as burial, mounding, or land farming were observed on the refinery property. The only mound of dark material identified by ERI was seen on a July 17, 1940, photograph. The mound was just south of the cooling water spray basins. The mounded material could have been the material excavated to construct the cooling water spray basins. The mound was gone in the June 1927, 1950 photograph, and the basins had been filled in and replaced with cooling towers built on the same location.

ERI identified a significant area of dark material (DK M) in a September 2, 1968, photograph. The DK M area was located in the northwest corner of the refinery process area. The dark material was probably coke fines and ground stained by black water, which blew, drained, and spilled out of the coke railroad hopper cars. This area is adjacent to the section of the railroad spur where the rail cars, which were filled with coke produced at the delayed coker, were apparently staged while waiting to be moved by the railroad. This dark area was not seen in the 1950 photograph, but does appear in the 1955 and later photographs, consistent with the construction of the delayed coker in the early 1950s.

ERI identified a number of features in the photographs as impoundments (IM). All of the ERI identified IMs on the refinery property were identified by Baker & O'Brien as being structures built for specific uses and were not waste disposal impoundments. The structures identified as IMs were the condensation pit, blowdown

tank, blowdown pit, sewer sump, water treating plant separator box, water treating plant basin, API separators, flume, and the east tank farm oil separator box.

Areas of stained ground in the tank farms appears to be limited to areas inside the tank dikes for a few tanks in the West Tank Farm. There does not appear to be a consistent pattern of dumping tank bottom sludge, removed from tanks, on the ground around the tanks.

There was no storm water containment basin to provide retention time for when storm water runoff mixed with refinery wastewater. The consequence of this fact was that the storm water runoff would produce a much higher than normal flow rate in the sewer piping and would flush out the contents of the sewer system, into the flume and API separators. The flume and separators, because of the much higher flow rates, would have very low oil and solids separation efficiency for this time period. Much of the oil and solids in the wastewater would not be recovered but would have been discharged out of the refinery, or overflowed into the ditches along the perimeter of the refinery if the Monsanto sewer system could not handle the flow.

The conclusion drawn from the aerial photographs is that most of the refinery produced solid wastes and sludges were not disposed of on refinery property, and therefore must have been taken offsite for disposal. It is possible that some of the tank bottom sludges from a few of the west tank farm tanks were spread out on the ground in the west tank farm as the method of disposal.

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## V. ESTIMATION OF THE QUANTITY OF WASTE GENERATED

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An order of magnitude estimate of the waste generated at the Refinery during its operating years of 1918 to 1970 has been prepared. The estimate consists of a build-up of individual waste streams expected to have been produced at the Refinery. A description of the method used for each stream follows. A summary of the estimated wastes can be found in Table I. The supporting calculations are included in Attachment X.

### SOLIDS CONTAINED IN THE REFINERY WASTEWATER DISCHARGE

A 1944 letter from Socony-Vacuum states that the estimated normal wastewater rate was 800-1,200 gpm. The 1951 Illinois pollution survey of the refinery states the water rate as 520 gpm. These water rates were most likely process water only and did not include storm water flow. Based on the stated solids load of 300 ppm in the wastewater discharge and a discharge rate of between 520 and 1,200 gpm, then an estimated 15,000 to 40,000 cubic yards of solids were released from the Refinery in the wastewater discharge during the Refinery's operating history. This estimate is based on one data point of solid load during normal operations. During periods of upset refinery operation or heavy rain, the solids load could be expected to be higher than 300 ppm. These solids could be coated with oil and contained heavy metals vanadium, nickel, lead, and chromium. Accepting that the water rates in both documents are accurate means the refinery achieved a significant reduction in wastewater flow rate between 1944 and 1951 while increasing refinery capacity from 20,000 to 30,000 B/D.

## **OIL CONTAINED IN THE REFINERY WASTEWATER DISCHARGE**

The 1951 Illinois survey states that there was typically 250 ppm of oil in the wastewater discharge. At a wastewater rate of between 500-1,200 gpm, then approximately 60,000 to 150,000 Bbls. of hydrocarbon (15,000 to 40,000 cubic yards) were released from the Refinery in the wastewater discharge during the Refinery's operating history. This estimate is based on one data point of oil load during normal operations. During periods of upset refinery operation or heavy rain, the solids load could be expected to be higher than 250 ppm. The oil would be a mixture of virgin and cracked hydrocarbons containing BTX, PAHs, phenols, and metals.

## **API SEPARATOR SLUDGE**

Two different volume estimation approaches were used. Discovery documents and deposition testimony provide an approximate size of the separators, and support that the solids were removed at some interval. Estimating a cleaning frequency of once every two years and a sludge depth of 30 inches, allowed for the calculation of the cubic yards of sludge per year to be disposed. The second approach was to use the range of separator sludge production stated in a 1957 *Oil & Gas Journal* article about the Humble Baytown refinery, divided by the Baytown crude capacity. This provided a range of factors proportional to refinery crude capacity. These factors were multiplied by the Refinery crude capacity to derive an approximation of API separator sludge for East St. Louis. The results for these two methods at a crude rate of 50,000 B/D for Refinery were comparable. The factor method was used to calculate sludge generation for the 1918-1970 time period.



## **TCC CATALYST**

Published articles about the TCC process provided typical rates for the production of catalyst fines and for the economic replacement rate for the whole catalyst beads. A fines generation rate of 0.1 pound per barrel of TCC capacity and an additional economic replacement rate of whole catalyst of 0.4 pounds per barrel of TCC capacity were used. The bulk density of fines and whole bead catalyst were provided in literature. The typical accumulation of vanadium and nickel on the catalyst for a TCC processing Mid-Continent crude oil was also found in literature allowing the estimation of the amount of both metals contained on the waste catalyst.

Most of the fines would be captured out of the exhaust gases exiting the TCC kiln. The remaining fines would be released into the atmosphere and into the TCC synthetic crude product tanks. The whole catalyst beads would have been removed from the TCC into hoppers or trucks. The waste catalyst would have been disposed.

## **WEAK ACID AND ALKALI NEUTRALIZATION TREATING SLUDGE**

Streams of weakened acid and alkali, which were the wastes from various processes in the refinery, could be collected to recover any residual free oil and to neutralized prior to disposal. Sludges could have existed in this collection system, and the sludges would be disposed. A sludge production factor per barrel of crude oil capacity was determined from the 1957 article on the Humble Baytown refinery waste production, and applied to the East St. Louis crude capacity through time.

## **SLOP OIL EMULSION TREATING SLUDGE**

The processing of emulsions captured from the sewer system, the crude desalter, and other sources would have resulted in the ultimate production of a stabilized, emulsified sludge, which must be disposed. A sludge production factor per Bbl. of crude oil capacity was determined from the 1957 article on the Humble Baytown refinery waste production, and applied to the East St. Louis crude capacity through time.

## **CRUDE OIL TANK BOTTOMS**

An estimate was made of the number of tanks likely used for crude oil based on a reasonable split of the available tankage between crude, intermediates and products. Aerial photographs of the refinery allowed for estimating changes in available tankage through time. Based on cleaning each crude oil tank once every ten years, and removing a six-inch accumulation, an estimate of crude oil tank bottoms was determined. A second estimate was made using a basic sediment content of 0.005% as have been settled out in tankage for the volume of crude processed. Both approaches provided comparable estimates.

## **LEADED GASOLINE TANK BOTTOMS**

An estimate was made of the number of tanks likely used for leaded gasoline based on a reasonable split of the available tankage between crude, intermediates, and products. Aerial photographs of the refinery allowed for estimating changes in available tankage through time. Based on cleaning each gasoline tank once

every ten years, and removing a three-inch accumulation, an estimate of leaded gasoline tank bottoms was determined.

## **DIESEL TANK BOTTOMS**

An estimate was made of the number of tanks likely used for diesel based on a reasonable split of the available tankage between crude, intermediates, and products. Aerial photographs of the refinery allowed for estimating changes in available tankage through time. Based on cleaning each diesel tank once every ten years, and removing a six-inch accumulation, an estimate of diesel tank bottoms was determined.

## **TCC SYNTHETIC CRUDE TANK BOTTOMS (CLARIFIED SLURRY TANK BOTTOMS)**

An estimate was made using two tanks for TCC synthetic crude. Based on cleaning each TCC synthetic crude oil tank once every five years, and removing a six-inch accumulation, an estimate of synthetic crude tank bottoms was determined.

## **HYDROTREATING AND POLYMER UNIT CATALYSTS**

These catalysts would have been disposed on a frequency typically between six to thirty-six months. The quantity is estimated to be well less than 50 cubic yards per year based on typical reactor size for the capacity of units at the Refinery.

## **SPENT TREATING CLAYS**

No estimate was made as the number and service of clay filters used at East St. Louis is unknown. The clay filters that existed would have to have the clay regularly replaced, with the used clay either being regenerated by burning or disposed.

## **COMMENTS ON THE WASTE ESTIMATION METHOD USING THE HUMBLE BAYTOWN DATA**

The method used to estimate the quantity of the three sludges previously identified in this section, was a method also used by the author of the 1990 American Petroleum Institute Discussion Paper #062, titled "An historical overview of solid waste management in the petroleum industry." The Paper #062 author stated that the Humble Baytown separator sludge production per barrel of crude oil was a lower value than one derived from a separate study of the U.S. refining industry sludge generation in 1981. The author suggests the Baytown sludge per barrel of crude oil values are low compared to the average of the refining industry. Therefore, the estimates provided in this report for the Refinery may be low compared to the industry average for the time period covered.

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## **VI. REFINERY WASTES IDENTIFIED IN SITES G, H, I, AND DEAD CREEK**

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### **THERMOFOR CATALYST**

Beads have been recovered from the Sites during sampling operations.

The beads were examined for their shape, size, color, external and internal surface appearance, and composition. The beads had a irregular spherical shape, varying from nearly spherical to egg shape. The beads had a size of approximately two to five millimeters in diameter. The bead color varied from grayish-white to gray, burnt orange, brown, and black. The brown and black colors appear to result from the sludge mixture the beads were mixed with in the recovered sample. The surface appearance under a microscope was grainy and textured. Upon breaking a couple beads apart, the internal surfaces at the break point were glassy. The bead composition was primarily silicon and aluminum with lower levels of iron, sulfur, and sodium. All these physical characteristics are consistent with Thermoform catalyst.

### **HYDROTREATING CATALYST**

Pellets have been recovered from the Sites during sampling operations.

The pellets were examined for their shape, size, color, external surface appearance, and composition. The pellets were cylindrical in shape. The pellets were approximately five to ten millimeters long and several millimeters in diameter and fairly consistent in size between pellets. A number of the pellets were broken. The pellets had a blue to blue-gray color. The surface under microscope was grainy and textured. The pellet

composition was primarily aluminum, silicon, molybdenum, and cobalt. All these characteristics are consistent with hydrotreating catalyst. The Refinery had a naphtha hydrotreating unit and a B-B treating unit.

## **METALS**

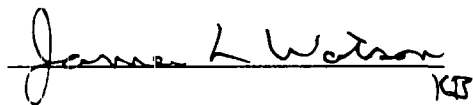
Elemental analysis of samples from Sites G, H, I, and Dead Creek identified varying levels of lead, vanadium, nickel, chromium, cobalt, and molybdenum which are metals believed to be present in portions of the solid wastes produced by the Refinery. It is believed the Refinery contributed to the levels of metals found, but was not the only possible source for these metals.

## **AROMATIC, POLYNUCLEAR AROMATIC, AND PHENOLIC HYDROCARBONS**

Elemental analysis of samples from Sites G, H, I, and Dead Creek identified varying levels of a host of aromatic, polynuclear aromatic, and phenolic hydrocarbons which are believed to have been present in portions of the solid wastes produced by the Refinery. Attachment IX contains a list of the specific hazardous substances, which include these aromatic, polynuclear aromatic, and phenolic hydrocarbons. It is believed the Refinery contributed to the levels of these hazardous substances found, but was not the only possible source for these substances.

All the opinions contained in this report are provided within a reasonable degree of engineering certainty. I reserve the right to amend or change my opinions should other pertinent facts become known to me.

Respectfully submitted this 11<sup>th</sup> day of October, 2002.

  
James L. Watson, P.E.



# APPENDIX A

## RESUME of JAMES L. WATSON, P.E.

**EDUCATION:** B.S. Magna cum Laude, Mechanical Engineering - 1983  
Southern Methodist University

M.B.A. - 2000  
University of Dallas

### EXPERIENCE:

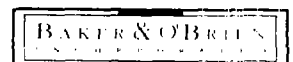
Baker & O'Brien, Inc. Senior Consultant	Current
Fina Oil and Chemical Company, TotalFina S.A. Corporate Planning Manager Planning and Business Development Coordinator	1996 - 2000
Exxon Corporation West Coast Refining Supply Coordinator Refining Planning and Economics Manager Operations Supervisor Maintenance Supervisor Distillate Coordinator and Economist Operations Engineer	1985 - 1996
NL Industries Well Logging and Completion Engineer	1983 - 1985
Sun Production Company (College Co-op) Production Engineer	1981 - 1982

### PROFESSIONAL REGISTRATION:

Professional Engineer -Texas (#86644), Louisiana (#25678), and  
Virginia (#0402 036694)  
American Society of Mechanical Engineers (ASME)

### SUMMARY OF EXPERIENCE:

Jim began his career with NL Industries in 1983, as an oil and gas well logging, completion, and pipe recovery engineer. His work involved a range of oil/gas field activities including perforations, cementing, plugging, stuck pipe removal, and flow detection of wells.



**Resume of James L. Watson, P.E.**  
**Page -2-**

In 1985, Jim joined Exxon Corporation as an Operations Engineer at the Baton Rouge refinery. Initially, he provided mechanical, instrumentation, and process engineering support to the delayed coking and fluid catalytic cracking complexes. His experience included development of capital projects, as well as planning and execution of multiple turnarounds.

During 1988, Jim served as the Distillate Coordinator and Economist, managing the production and distribution of diesel, heating oil, commercial, and military jet fuels from the Baton Rouge refinery. Beginning in 1989, Jim gained experience as both Maintenance Supervisor for the utilities systems and Operations Supervisor for the power distribution, hazardous waste, asbestos abatement, and fugitive emissions programs. Jim led efforts to reduce the cost of handling hazardous waste and asbestos, deployed data systems into the field to improve efficiency, and brought pacesetter maintenance practices to off-site facilities.

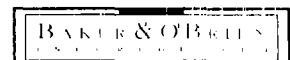
Next, Jim became Operations Supervisor of the fuels and lube crude distillation complex. He was responsible for daily operations, operating budgets, improvement plans, and personnel. His work helped to improve the quality and yield of lube basestocks, increase the flexibility to process corrosive and heavy crude, and to optimize the process in real-time.

During 1993-1996, Jim was the Refinery Planning and Economics Manager. His team of engineers developed refinery run plans, determined economic signals, and provided direction to the commercial groups. During Jim's tenure, the refinery increased the processing of low cost raw materials such as heavy, sour crude oils, and long residua (to the FCCU) with minimal capital investment. The refinery also increased feed and byproduct exchanges with the adjacent chemical complex, generating significant cost savings.

In 1996, he became the West Coast Refining Supply Coordinator, optimizing the logistical, commercial, and marketing functions of products and intermediates for Exxon's Benicia refinery. Jim was closely involved with the introduction of CARB gasoline which occurred during this period.

Late in 1996, Jim joined Fina Oil and Chemical as Planning and Business Development Coordinator. His efforts included improvements to the short-range economics and planning process; acquisition, divestiture, and joint venture evaluations; and capital investment development. Jim provided financial, technical, and negotiation expertise to the BASF-FINA joint venture steam cracker being built and integrated with the Fina Port Arthur Refinery, and a future joint venture butylene processing complex. Most recently, he was Corporate Planning Manager responsible for coordinating the U.S. capital investment plans, leading special strategic studies, and providing business support to the CEO and CFO.

Jim joined Baker and O'Brien in February 2000.



**REPRESENTATIVE MAJOR PROJECT EXPERIENCE:**

1. **Refinery Planning and Economics** – Reviewed existing work and communication processes between the refinery and company headquarter personnel. Recommendations included a new LP model platform, structured evaluation methods, standardized schedule and reports, a rolling four-week plan, and hindsight evaluation.
2. **Ethylene Plant Economic Evaluation** – Performed financial evaluations for a grass roots Gulf Coast ethylene plant, and market valuation of an existing Gulf Coast ethylene plant to determine whether the company should build or buy ethylene capacity.
3. **Refinery and Marketing Joint Venture Valuations** – Evaluated potential synergies of U.S. downstream joint ventures between several integrated oil companies, assessing the market value of the individual company's downstream assets, and the potential combined value.
4. **Refining and Steam Cracking Synergies** – Worked on interface issues and development of synergies for two different refining and chemical complexes. Both efforts identified over \$50 million in annual synergies by integrating a refinery and a liquids based steam cracker.
5. **Crude Selection LP** – Evaluated whether advanced non-linear optimization platforms provide an economic advantage compared to traditional linear programs for crude selection. Company was advised that the uncertainties in crude and product pricing, crude qualities, and actual refinery operations far exceed the gain in accuracy due to advanced non-linear modeling. Focus was directed to improving crude assay data and refinery unit performance.
6. **Crude Logistics** – Led study to improve crude logistics short term and identify direction for long term. Results included adding a connection to a major Gulf Coast crude pipeline allowing the company to reduce third party storage and working capital in excess of \$5 million. Modeling identified the optimal amount of refinery storage and dock space required for economic flexibility and refinery growth requirements.
7. **Pipeline Easement Dispute** – Served as expert witness on pipeline installation, monitoring, testing, and repair, in a dispute concerning development of property transected by existing pipelines.

8. **Delayed Coker Feed Study** – Assisted in optimizing anode coke production from a refinery with multiple crude and delayed coking units. This optimization was accomplished by segregating residua used for production of anode grade coke from fuel grade coke. The results included a decrease in crude oil acquisition costs and an increase in overall coke revenue.
9. **Heavy Crude Upgrading Studies** – Evaluated the economic feasibility of Orinoco heavy crude upgrading in Venezuela and in a Gulf Coast refinery. Study included visbreaking, coking, supercritical extraction, hydroconversion, and hydrotreating scenarios.
10. **Olefins Pipeline Study** – Led study and negotiations to secure pipeline capacity for olefins from grass roots ethylene plant. Explored joint ventures, service conversions, owner construction, and third party alternatives. Executed contract with third party to leverage the company's capital outlay, and led team to set the design parameters.
11. **Butylenes Processing Joint Venture** – Performed financial evaluation and assisted in process development of investments to upgrade butylenes for a joint venture chemical company. Processes evaluated included butadiene extraction and hydrogenation, MTBE, iso-octane, metathesis for propylene, skeletal isomerization, and dimerization. Company is progressing grass roots project after considering other joint ventures and toll processing arrangements.
12. **National Petroleum Council (NPC) Committee on Refining** – Acted as committee member of the NPC and DOE sponsored study to assess the future viability of the domestic refining industry due to the impact of continued environmental regulations, including low sulfur gasoline and diesel.
13. **Accident Investigation** – Led team investigating a vapor cloud ignition and subsequent fire which resulted in \$1 million in equipment damage and personal injury.
14. **Refinery Turnarounds** – Provided engineering support on over 15 major refinery unit turnarounds on crude units, delayed cokers, and fluid catalytic cracking units, ranging in cost from \$5 to \$30 million each.

## APPENDIX B

### JAMES L. WATSON TESTIMONY AND DEPOSITION HISTORY (1997-Present)

<i>Date</i>	<i>Matter</i>
2002	Transpetco Pipeline Company L.P. Arbitration
2002	Andry et al v. Murphy Oil USA v. ARCO et al.
2001	Robert Hudson et al v. Mobil Oil Corporation and Triple "S" Industrial Corporation
2000	Williams Pipeline v. Allison & Alexander, Inc., et al.

# APPENDIX C

## DOCUMENTS REVIEWED

### STUDIES

"Draft Land-Use History of Sauget Area 1", PHR Environmental Consultants Incorporated, December 5, 1999

"Engineering Evaluation / Cost Analysis Remedial Investigation / Feasibility Study Sauget Area 1, Sauget and Cahokia, Illinois, March 9, 2001, United States Environmental Protection Agency

"Sauget Area 1 and 2 Sites, Volume 1 - Area Data Tables/Maps", prepared by Ecology and Environmental Incorporated, February 1998 - Bates US 06861 - 07914

### DISCOVERY

"Mobil Oil Corporation, East Saint Louis Refinery, General Description", H.F. Killebrew, April 20, 1961

Memo concerning reversal of flow in Monsanto sewer system, to Mr. J.W. Goldenberg, Consulting Engineer from Mr. A.E. Williamson, Mobil Oil Company, East Saint Louis Refinery, November 13, 1964. Bates 906SA

Memo concerning site visit to East Saint Louis terminal and interview of Mr. Oscar McGuire, to Division of Water Pollution Control, Surveillance Section, from Mr. M.G. Neumann, February 13, 1973. Bates IW0251

"Report Upon Separation Of Sewers In The Village Of Monsanto, Illinois For Monsanto Chemical Company", Jos. W. Goldenberg, Consulting Engineer, March 15, 1962, Bates CER178106

### PUBLISHED LITERATURE

"Disposal Of Refinery Wastes - Section I, Waste Water Containing Oil", 2<sup>nd</sup> Edition 1933, American Petroleum Institute, Division of Refining

"Disposal Of Refinery Wastes - Section II, Waste Gases, Vapors, Sludges, and Dusts", 2<sup>nd</sup> Edition 1938, American Petroleum Institute, Division of Refining

"Disposal Of Refinery Wastes - Section III, Waste Water Containing Solutes", 1<sup>st</sup> Edition 1935, American Petroleum Institute, Division of Refining

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## DOCUMENTS REVIEWED

"Annual Petroleum Refining Capacity Survey", The Oil and Gas Journal, 1917 through 1971.

"Petroleum Refinery Engineering", 4<sup>th</sup> Edition 1958, W.L. Nelson, McGraw-Hill Book Company

"Petroleum Refinery Engineering", 3<sup>rd</sup> Edition 1949, W.L. Nelson, McGraw-Hill Book Company

"Petroleum Refinery Engineering", 2<sup>nd</sup> Edition 1941, W.L. Nelson, McGraw-Hill Book Company

"Disposal of Refinery Wastes", Petroleum Refiner, July, 1946

"The History of Bright Stock Manufacture", Petroleum Refiner, November, 1930

Disposal of Refinery Wastes, a series of 13 (out of 20 published) articles, Petroleum Processing in monthly issues September 1946 through September 1947

API RP-2015 "Recommended Practice for Cleaning Petroleum Storage Tanks",

"Tank Cleaning Manual - lead hazard aspects of cleaning leaded-gasoline storage tanks" issued by the Ethyl Corporation, 1971

"Modern Refinery's Methods Described", Oil and Gas Journal, April 5, 1923

"Recovering Sludge Acid at Refineries", Oil and Gas Journal, March 10, 1927

"Development in Petroleum Refining", Oil and Gas Journal, March 10, 1927

"Acid-Sludge Problem in Oil Refining", Oil and Gas Journal, August 1, 1928

"Refining of Petroleum Distillates", Oil and Gas Journal, March 7, 1929

"Chemical Processes in refining of Petroleum Distillates", Oil and Gas Journal, March 26, 1936 and April 2, 1936 and April 9, 1936

"Filtration of Refinery Emulsions and Separator Sediment", Oil and Gas Journal, March 23, 1950

"Chemical Cleaning of Refining Equipment", Oil and Gas Journal, March 23, 1953

"Selected Plant Process Descriptions", Oil and Gas Journal, March 25, 1957

# APPENDIX C

## DOCUMENTS REVIEWED

"Here is what's new in delayed coking", Oil and Gas Journal, April 6, 1970

"How Monsanto village handles its wastes", Oil and Gas Journal, March 28, 1966

"Baytown refinery's clean-air and water program", Oil and Gas Journal, March 28, 1966

"Humble attacks pollution at Baytown", Oil and Gas Journal, October 5 and October 12, 1959

"Cracking Process for Small Refinery", Oil and Gas Journal, February 26, 1925

"Innovative Improvement Highlight FCC's Past and Future", Oil and Gas Journal, January 8, 1990

"Problems in Handling Filter Cakes", Refiner & Natural Gasoline Manufacturer, February, 1934

"Sludge...", Refiner & Natural Gasoline Manufacturer, May, 1934

"Recent Developments in TCC Cracking", Proceeding Fourth World Petroleum Congress-Section III/E, Presented by J.W. Wayne (Socony-Mobil), June 7, 1955

"Combustion of Coke Deposit on Synthetic Bead Cracking Catalyst", Oil and Gas Journal, March 15, 1947

"Solids Waste Disposal", Oil and Gas Journal, March 3, 1958

"Distribution of metal contaminants on cracking catalysts", Paper presented at American Chemical Society, Division of Petroleum Chemistry, Dallas Meeting, April 8-13, 1956

"Earnings - a function of catalyst activity", The Petroleum Engineer, August, 1946

"Catalytic Cracking in Airlift TCC Units", The Petroleum Engineer, August, 1952

"Lubrite converts fuel oil into more profitable products", National Petroleum News, May 6, 1936

"The Science of Petroleum, Volume II - History and Development of Some Important Phases of Petroleum Refining in the United States", Dr. A.E. Dunstan, Oxford University Press, 1938



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## DOCUMENTS REVIEWED

"Manual on Disposal of Refinery Wastes, Volume I - Waste Water Containing Oil", 7<sup>th</sup> Edition, American Petroleum Institute, 1963

"Manual on Disposal of Refinery Wastes, Volume VI - Solid Wastes", 1<sup>st</sup> Edition, American Petroleum Institute, 1963

40 CFR Part 261, Hazardous Waste Management System; Identification and Listing of Hazardous Waste

"An Historical Overview Of Solid Waste Management In The Petroleum Industry", discussion paper #062, Jody Perkins, October 1990

"API Refining Study Spotlights Wastes", Oil and Gas Journal, May 20, 1968

"Waste Disposal in Retrospect", W.B. Hart, from the Proceedings of the American Petroleum Institute, Section III Refining, 36<sup>th</sup> Annual Meeting, 1956

**ATTACHMENTS**

# ATTACHMENT I-A

## ESTIMATE OF CUMULATIVE PROCESS SOLID WASTE

### 1918 - 1970

<i><b>Waste Stream</b></i>	<i><b>Total Quantity Cubic Yards</b></i>	<i><b>Potential Hazardous Constituents</b></i>	<i><b>Basis</b></i>
API Separator Sludge	4,000-13,000	BTX, PAH, Pb, V, Ni, Cr, Phenols	1957 Humble Baytown comparison, Discovery documents
TCC Catalyst - Fines	14,000	3,000 pounds Ni	Industry publications
Whole	58,000	6,000 pounds V	
Acid / Alkali Neutralization Treating Sludge	27,000	BTX, PAH, Phenols	1957 Humble Baytown comparison
Slop Oil Emulsion Treating Sludge	25,000	BTX, PAH, Pb, V, Ni, Cr, Phenols	1957 Humble Baytown comparison
Crude Tank Bottoms	7,000	V, Ni, PAH	Industry publications Discovery documents
Leaded Gasoline Tank Bottoms	8,500	BTX, Pb	Industry publications Discovery documents
Distillate Tank Bottoms	7,000	PAH, Phenols	Industry publications Discovery documents
TCC Syn. Crude Tank Bottoms	1,500	PAH, Phenols, V, Ni	Industry publications Discovery documents
Hydrotreating, Poly Catalysts	<750	BTX, Co, Mo	Industry publications Discovery documents

**ATTACHMENT I-A**  
**(Continued)**  
**ESTIMATE OF CUMULATIVE PROCESS SOLID WASTE**  
**1918 - 1970**

<b><i>Waste Stream</i></b>	<b><i>Total Quantity Cubic Yards</i></b>	<b><i>Potential Hazardous Constituents</i></b>	<b><i>Basis</i></b>
Spent Treating Clays	no estimate	PAH, BTX, Phenols	Industry publications
Heat Exchanger Cleaning Sludge	no estimate	PAH, Pb, V, Ni	Industry publications Discovery documents
<b>Total Solid Waste</b>	<b>~150,000</b>		

**ATTACHMENT I-B**  
**ESTIMATE OF CUMULATIVE WASTE IN WASTE WATER DISCHARGE**  
**1918 - 1970**

<b><i>Waste Stream</i></b>	<b><i>Total Quantity Cubic Yards</i></b>	<b><i>Potential Hazardous Constituents</i></b>	<b><i>Basis</i></b>
Solids in Waste Water Discharge	16,000-37,000	V, Ni, Pb, Cr	Industry publications Discovery documents
Oil in Waste Water Discharge	13,000-31,000 65-150 MBbls.	BTX, PAH, Pb, V, Ni, Cr, Phenols	Industry publications Discovery documents

# **ATTACHMENT II** **MID-CONTINENT CRUDE OIL ASSAYS**

<i>Crude</i>	<i>Mid-Continent Oklahoma</i>	<i>Illinois</i>	<i>Mid-Continent Pipeline</i>	<i>Steamboat Butte Wyoming Sour</i>
Assay Date	11/08/29	11/01/49	03/09/50	05/05/52
Gravity, °API	40.9	37.5	38.4	28.0
Sulfur, %	N/A	0.22	0.37	2.15
Gasoline IBP - 400°F, %	37.8	33.7	35.2	21.7
Octane, clear	46.0	51.2	51.6	45.0
Jet Stock - 400°F - 550°F, %	56.0	50.7	53.1	38.0
Kerosene - 375°F - 500°F, %	15.5	15.4	15.0	13.4
Gravity, °API	43.8	42.5	42.0	41.3
Sulfur, %	N/A	0.07	0.15	0.50
Diesel 400°F - 700°F, %	32.2	30.6	26.6	33.9
Cracking Stock, 400°F - 900°F, %	49.2	44.8	43.0	52.8
Gravity, °API	35.0	33.1	34.9	28.5
Cracking Stock, above 550°F, %	44.0	48.3	44.9	60.7
Gravity, °API	27.1	21.5	21.5	15.2
Lube Distillate, 700°F - 900°F, %	17.0	14.2	16.4	18.9
Sulfur, %	N/A	0.35	0.73	2.61
Residue, above 900°F, %	13.0	20.5	19.8	24.7

# ATTACHMENT III EAST ST. LOUIS REFINERY CAPACITY HISTORY

(Barrels Per Calendar Day Unless Noted)

Year	Company	Crude	Coker	Cat Crack	Cat Reform	Thermal Cracking	Cat H <sub>2</sub> Treat	Alky	Poly	Coke (T/D)	Treaters	Products
1918 <sup>(1)</sup>	Luberite Refining	650										Lube oil
1920 <sup>(3)</sup>		1,000										Lube oil
1921 <sup>(3)</sup>		1,000										Lube oil
1922 <sup>(3)</sup>		1,000										Lube oil
1924 <sup>(3)</sup>		3,000				Fleming stills						Lube oil
1923 <sup>(1)</sup>		3,500				Fleming stills						Stopped lube oil. Gasoline, Kerosene Gas Oil, Fuel Oil
1926 <sup>(3)</sup>		3,000				Fleming stills						
1927 <sup>(3)</sup>		4,000				1,200 Fleming						
1928 <sup>(2)</sup>		4,000										
1928 <sup>(3)</sup>		4,000				1,200 Fleming						
1929 <sup>(3)</sup>		4,000				1,200 Fleming						
1930 <sup>(3)</sup>		4,000				1,200 Fleming						
1932 <sup>(3)</sup>	Luberite Refining, Subsidiary of Vacuum Oil	3,500				2,500 Pratt Vapor Phase						
1933 <sup>(3)</sup>		3,500				2,500 Pratt Vapor Phase						
1934 <sup>(3)</sup>	Luberite Refining, Subsidiary of Socony- Vacuum Oil	4,750				3,200 Pratt Vapor Phase						
1935 <sup>(4)</sup>			4 Knowles coke ovens 1,000									
1935 <sup>(3)</sup>	Socony-Vacuum Oil Co., Inc. (Lubrite) East St. Louis	4,750				3,200 Pratt Vapor Phase, Cross						
1936 <sup>(3)</sup>		5,000				3,600 Pratt Vapor Phase, Cross						
1937 <sup>(3)</sup>		6,000				4,000 Pratt						
1938 <sup>(3)</sup>		7,200				4,750 Pratt						

ATTACHMENT III  
(Continued)  
EAST ST. LOUIS REFINERY CAPACITY HISTORY

(Barrels Per Calendar Day Unless Noted)

Year	Company	Crude	Coker	Cat Crack	Cat Reform	Thermal Cracking	Cat H <sub>2</sub> Treat	Alky	Poly	Coke (T/D)	Treaters	Products
1939 <sup>(3)</sup>		7,000				2,200 Pratt Vapor						
1939 <sup>(1)</sup>		12,000	4 coke ovens			Fleming stills removed						
1940 <sup>(3)</sup>		7,000				2,200						
1941 <sup>(1)</sup>			6 coke ovens								Gasoline Fuel oil	
1941 <sup>(3)</sup>		16,000				12,800 Pratt V.P. & Houdry						
1942 <sup>(3)</sup>		16,000				4,400 Pratt V.P. & Houdry						
1943 <sup>(1)</sup>												100 avgas
1943 <sup>(3)</sup>		16,000				4,800						
1944 <sup>(3)</sup>				Building TCC and HF Alky (completion spring 1944)								
				First TCC (bucket lift)				1,500 HF				
1944 <sup>(1)</sup>												
1945 <sup>(3)</sup>		20,000				2,000						
1946 <sup>(3)</sup>		20,000		18,000 TCC & Houdry		Exists but unidentified		1,670 HF				
1947 <sup>(3)</sup>		21,000		27,180 Total cracking unidentified								
1948 <sup>(3)</sup>		20,000		24,400 Total cracking unidentified								
1949 <sup>(3)</sup>		22,700		18,000 TCC & Houdry		2,800 thermal, 2,700 visbreaking						
1949 <sup>(1)</sup>		Second unit Desalter									Gasoline caustic tannin	



**ATTACHMENT III**  
**(Continued)**  
**EAST ST. LOUIS REFINERY CAPACITY HISTORY**

(Barreis Per Calendar Day Unless Noted)

Year	Company	Crude	Coker	Cat Crack	Cat Reform	Thermal Cracking	Cat H <sub>2</sub> Treat	Alky	Poly	Coke (T/D)	Treaters	Products
1950 <sup>(3)</sup>		30,000		18,000 TCC & Houdry		2,700 Visbreaking		1,500				
1950 <sup>(1)</sup>			2 drum coker		Reformer	Gas oil cracker						
1951 <sup>(3)</sup>		30,000		18,000 TCC & Houdry		11,700 total including coker		1,500				
1952 <sup>(3)</sup>		30,000		18,000 TCC & Houdry		11,700 total including coker		1,500				
1953 <sup>(3)</sup>		40,000	9,000	24,000	2,700	1,500		1,500				
1954 <sup>(3)</sup>		42,180	9,900	17,760 TCC	2,775	3,300						
1954 <sup>(1)</sup>				Second TCC (air lift) Houdry dismantled								
1955 <sup>(3)</sup>		42,200	9,900	29,100 TCC	2,750	3,300		1,500 HF	500 Cat.	266		
1956 <sup>(3)</sup>	Socony- Mobil Oil Co.	40,000	10,000	33,000 TCC	5,600 Building Sovaformer & Sovafiner			2,500 HF	650	300		
1957 <sup>(1)</sup>					PtR (Platinum Reformer)							
1957 <sup>(3)</sup>		40,000	10,500	33,000 TCC	12,000			2,580	670	300		
1958 <sup>(1)</sup>			Added 3rd drum									
1958 <sup>(3)</sup>		40,000	10,700	28,100	8,500 Socony		16,000 Naphtha	2,700	700	300		
1959 <sup>(3)</sup>	Mobil Oil Co.	45,200	12,700	27,800 (8,300 is recycle)	8,500		16,000 Naphtha	2,600	700	400		
1960 <sup>(3)</sup>		45,200	12,700	30,000 TCC	9,670		16,000 Naphtha	2,600 HF	700	400		

**ATTACHMENT III**  
**(Continued)**  
**EAST ST. LOUIS REFINERY CAPACITY HISTORY**

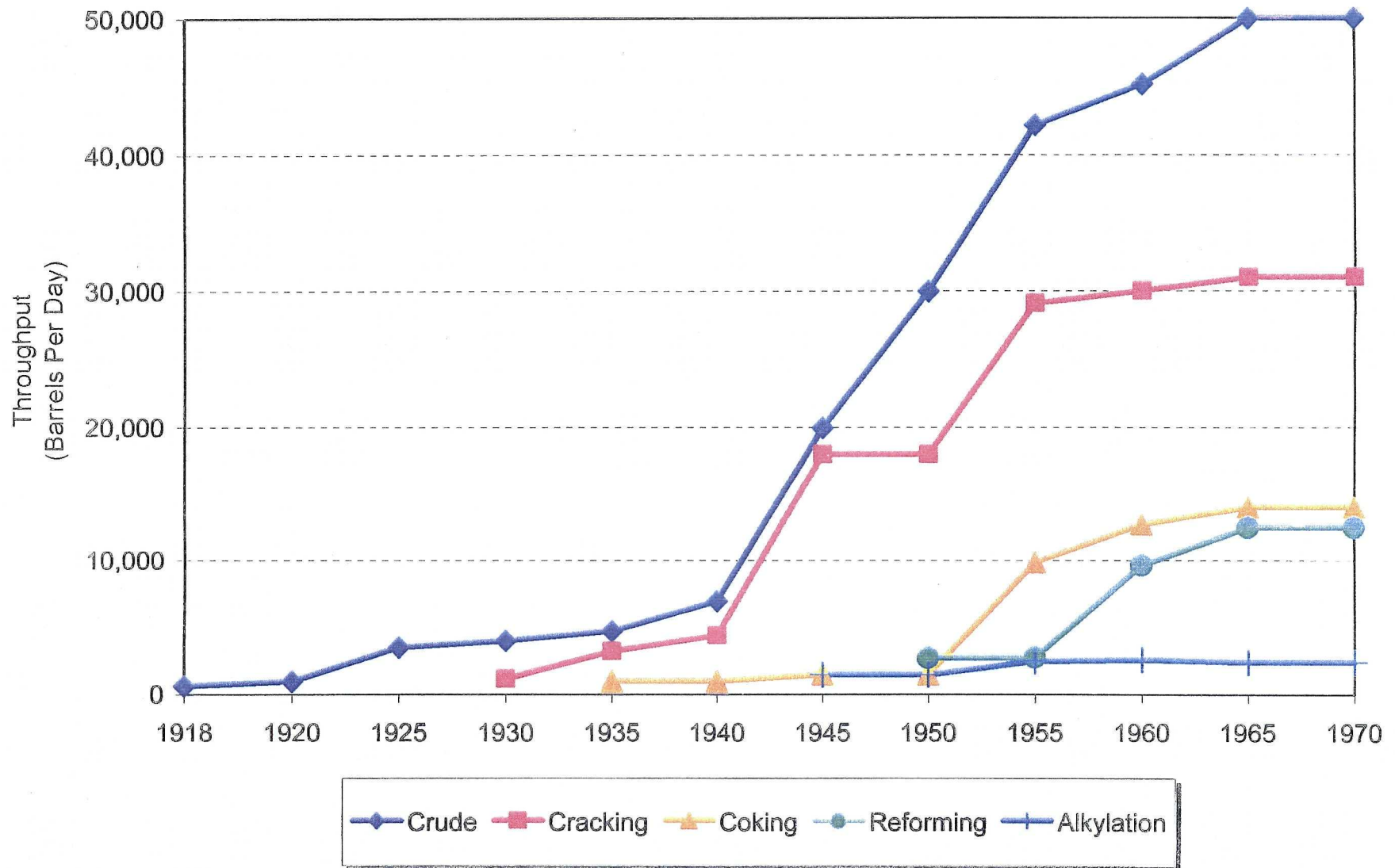
(Barrels Per Calendar Day Unless Noted)

Year	Company	Crude	Coker	Cat Crack	Cat Reform	Thermal Cracking	Cat H <sub>2</sub> Treat	Alky	Poly	Coke (T/D)	Treaters	Products
1961 <sup>(1)</sup>		50,000										
1961 <sup>(3)</sup>		50,000	13,000	Fresh 23,000 Recycle 8,000	12,000		16,000 SR Naphtha	2,400 HF	600	300		
1962 <sup>(3)</sup>		50,000	13,000	Fresh 23,000 Recycle 8,000	12,000		16,000 SR Naphtha	2,400 HF	600	300		
1963 <sup>(3)</sup>		50,000	13,000	Fresh 23,000 Recycle 8,000	12,500		17,000 SR & Thermal	2,400 HF	600	300		
1964 <sup>(3)</sup>		50,000	14,000	Fresh 23,000 Recycle 8,000	12,500		17,000 SR & Thermal	2,400 HF	600	400		
1965 <sup>(3)</sup>		50,000	14,000	Fresh 23,000 Recycle 8,000	12,500		17,000 SR & Thermal	2,400 HF	600	400		
1966 <sup>(3)</sup>		50,000	14,000	Fresh 23,000 Recycle 8,000	12,500		17,000 SR & Thermal	2,400 HF	600	400		
1967 <sup>(3)</sup>		50,000	14,000	Fresh 23,000 Recycle 8,000	12,500		17,000 SR & Thermal	2,400 HF	600	400		
1968 <sup>(3)</sup>		50,000	14,000	Fresh 23,000 Recycle 8,000	12,500		17,000 SR & Thermal	2,400 HF	600	400		
1969 <sup>(3)</sup>		50,000	14,000	Fresh 23,000 Recycle 8,000	12,500		17,000 SR & Thermal	2,400 HF	600	400		
1970 <sup>(3)</sup>		50,000	14,000	Fresh 23,000 Recycle 8,000	12,500		17,000	2,400		400		
1971 <sup>(3)</sup>	Shutdown in 4/6/71 Issue											

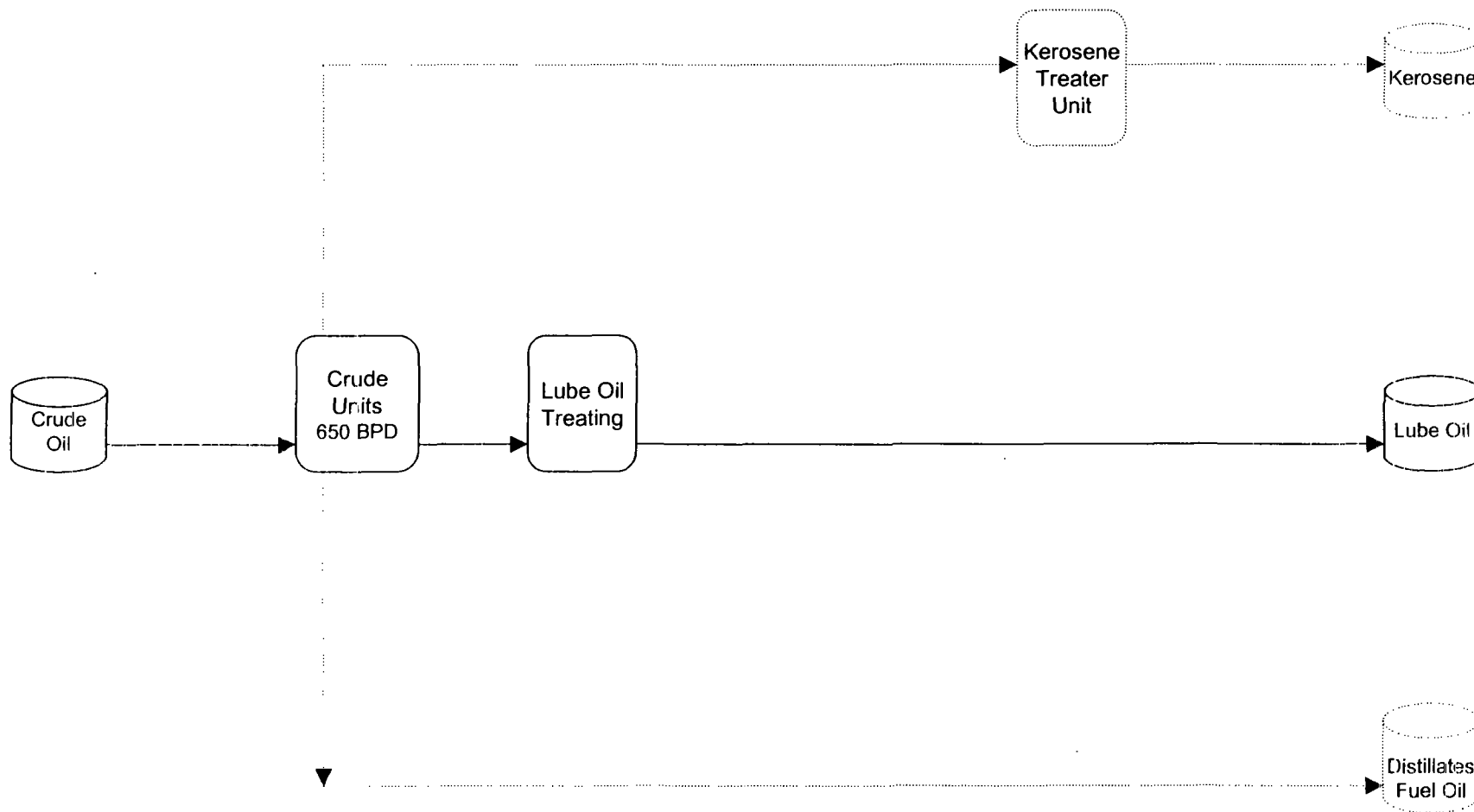
**SOURCES:**

- (1) Mobil document, "The History of the Refinery," 1961, written by G. Killebrew.
- (2) "Monsanto, Illinois: Facts to Consider in Selecting a New Plant Site," 1928.
- (3) *Oil & Gas Journal's* "Annual Survey of Operating Refinery Capacity."
- (4) "Lubrite Converts Fuel Oil Into More Profitable Products," *National Petroleum News*, May 6, 1936.

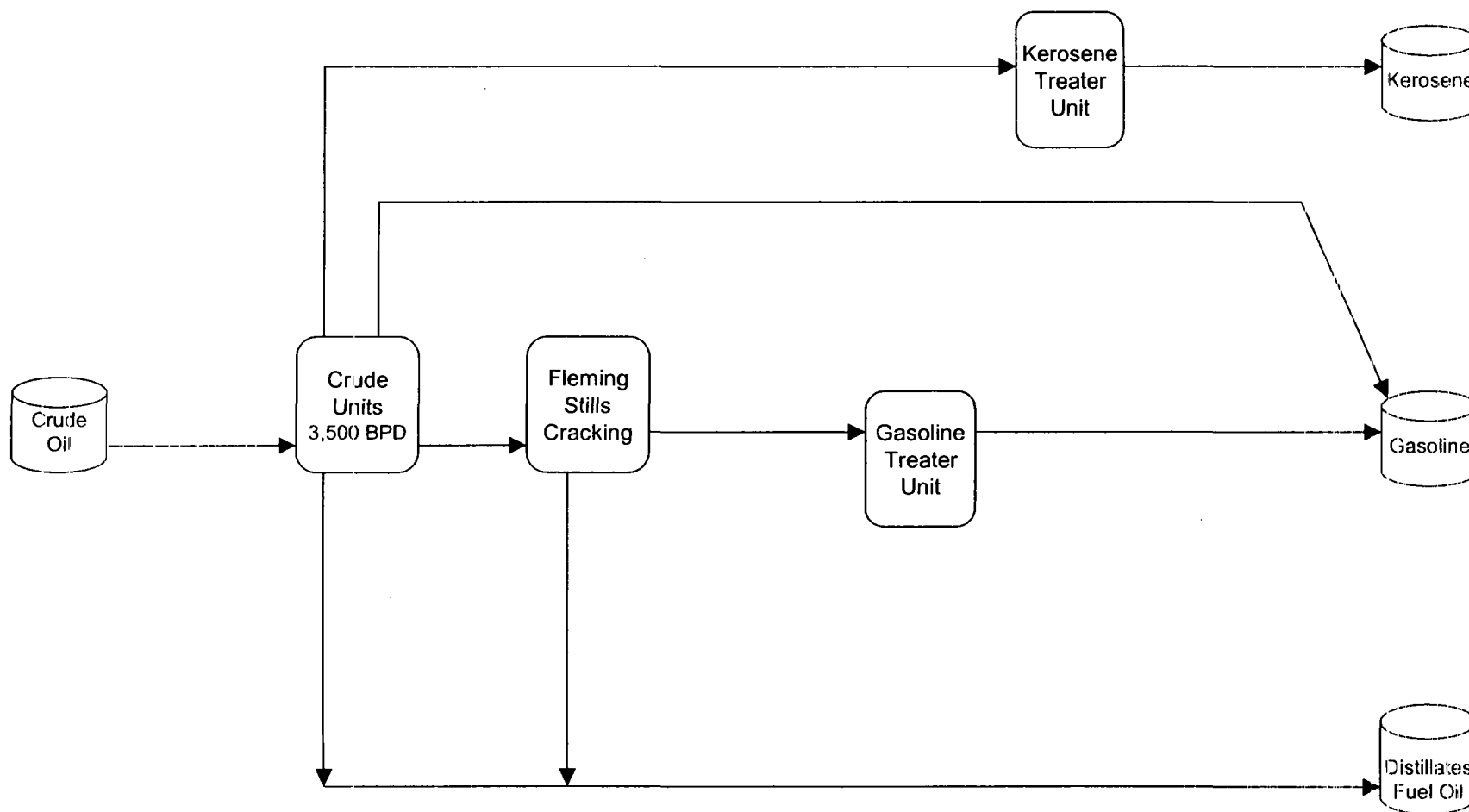
# ATTACHMENT IV MOBIL EAST ST. LOUIS REFINERY CAPACITY



**ATTACHMENT V**  
**ESTIMATED CONFIGURATION OF THE EAST ST. LOUIS REFINERY**  
**1918**



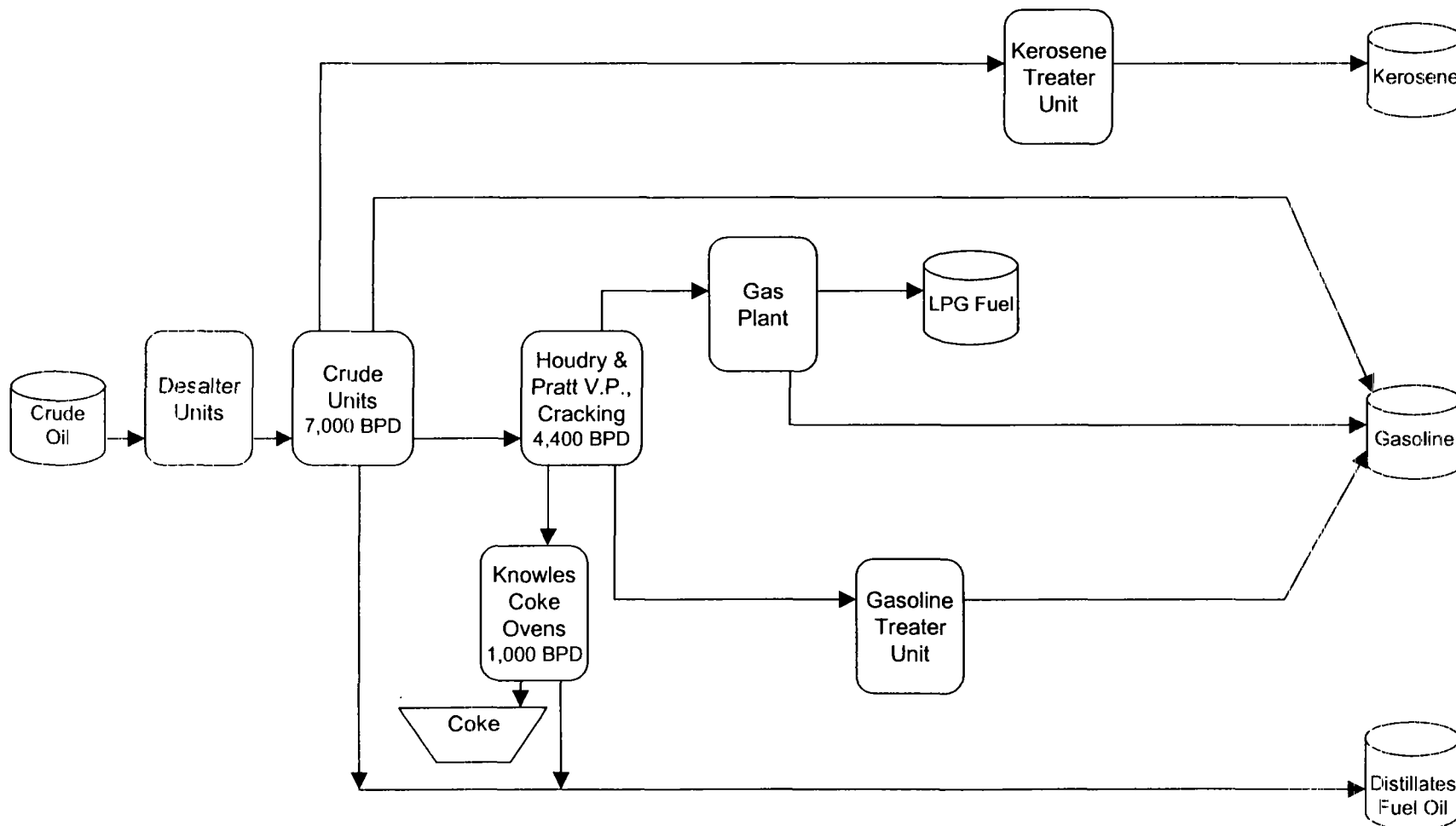
**ATTACHMENT V**  
**(Continued)**  
**ESTIMATED CONFIGURATION OF THE EAST ST. LOUIS REFINERY**  
**1923**



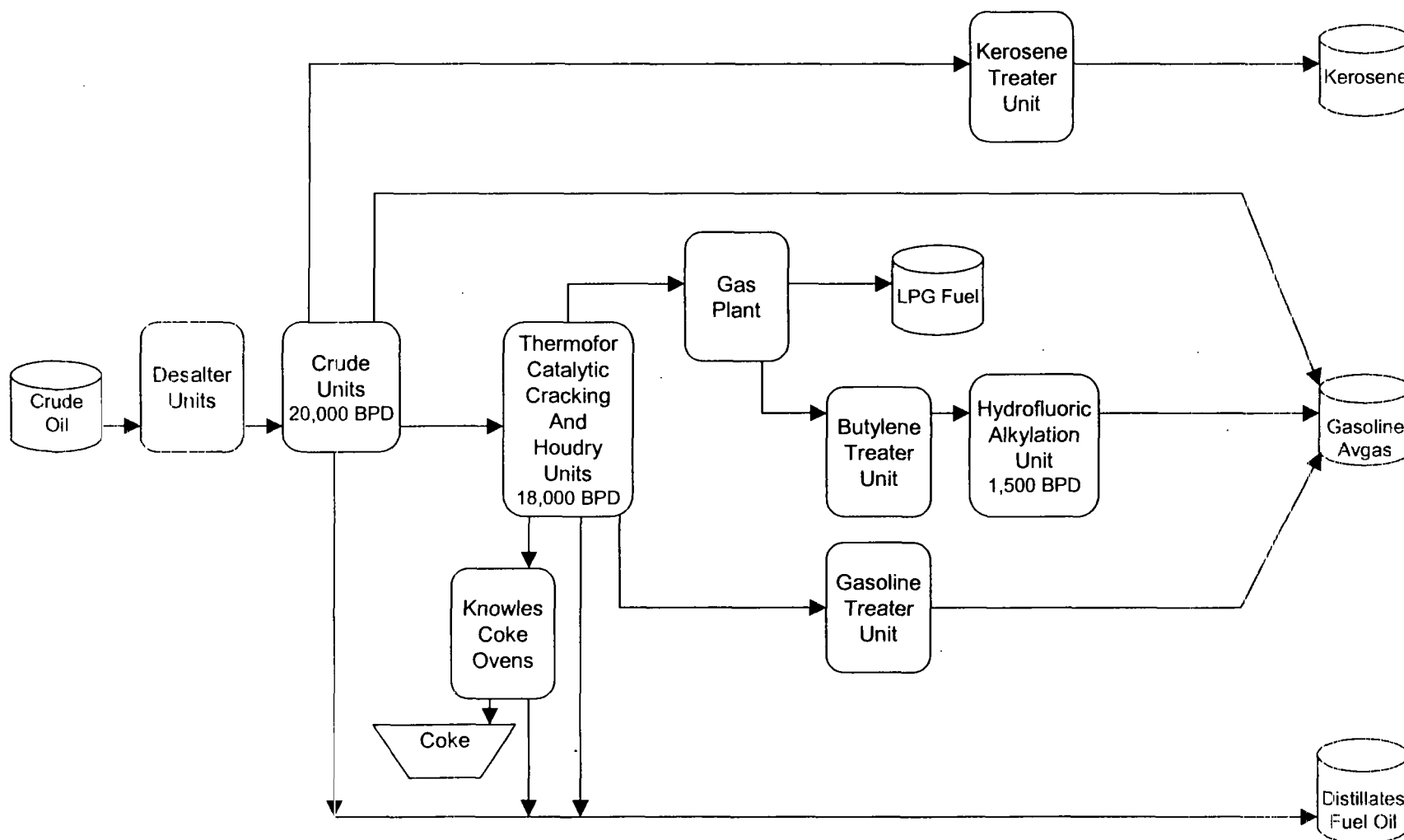
The diagram illustrates the following process flow:

- Crude Oil** (Storage Tank) → **Desalter Units** (Process Unit) → **Crude Units 4,750 BPD** (Process Unit).
- Crude Units 4,750 BPD** → **Pratt, Cross Thermal Cracking 3,200 BPD** (Process Unit).
- Crude Units 4,750 BPD** → **Kerosene Treater Unit** (Process Unit) → **Kerosene** (Storage Tank).
- Crude Units 4,750 BPD** → **Distillates Fuel Oil** (Storage Tank).
- Pratt, Cross Thermal Cracking 3,200 BPD** → **Knowles Coke Ovens 1,000 BPD** (Process Unit).
- Knowles Coke Ovens 1,000 BPD** → **Coke** (Storage Tank).
- Pratt, Cross Thermal Cracking 3,200 BPD** → **Gas Plant** (Process Unit) → **LPG Fuel** (Storage Tank).
- Pratt, Cross Thermal Cracking 3,200 BPD** → **Gasoline Treater Unit** (Process Unit).
- Gas Plant** → **Gasoline** (Storage Tank).
- Gasoline Treater Unit** → **Gasoline** (Storage Tank).
- Gasoline** (Storage Tank) → **Distillates Fuel Oil** (Storage Tank).

**ATTACHMENT V**  
**(Continued)**  
**ESTIMATED CONFIGURATION OF THE EAST ST. LOUIS REFINERY**  
**1940**

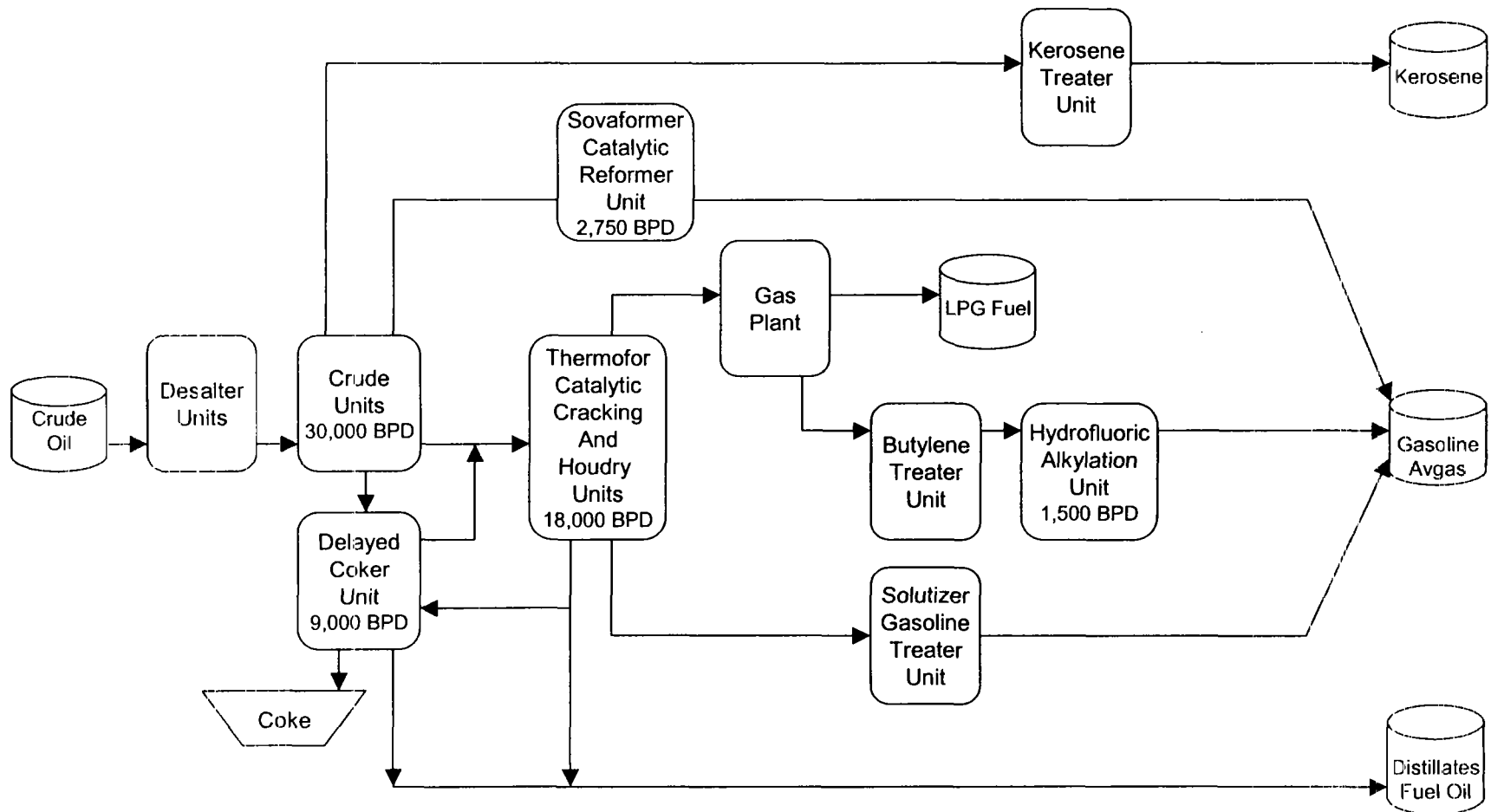


**ATTACHMENT V**  
**(Continued)**  
**ESTIMATED CONFIGURATION OF THE EAST ST. LOUIS REFINERY**  
**1945**

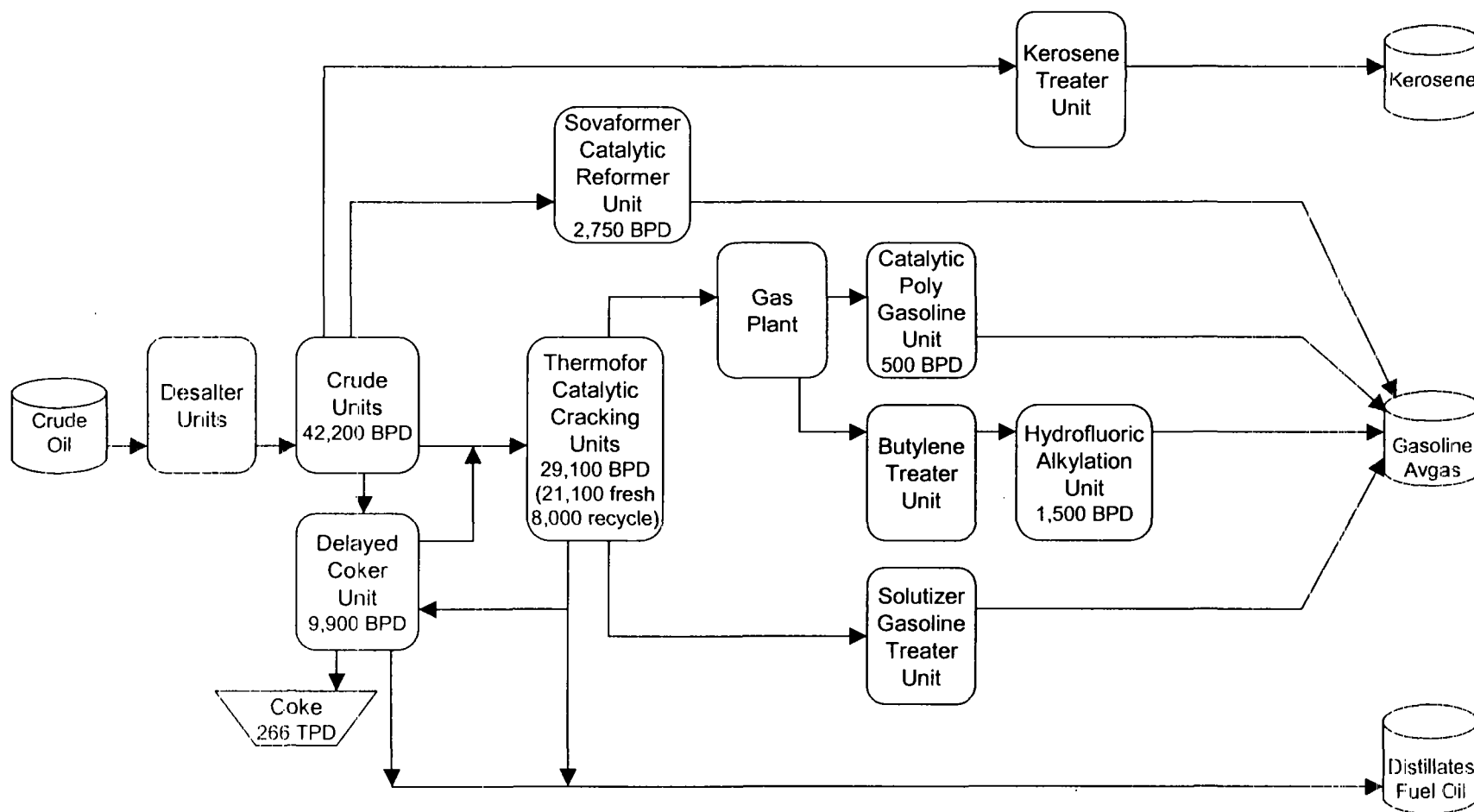




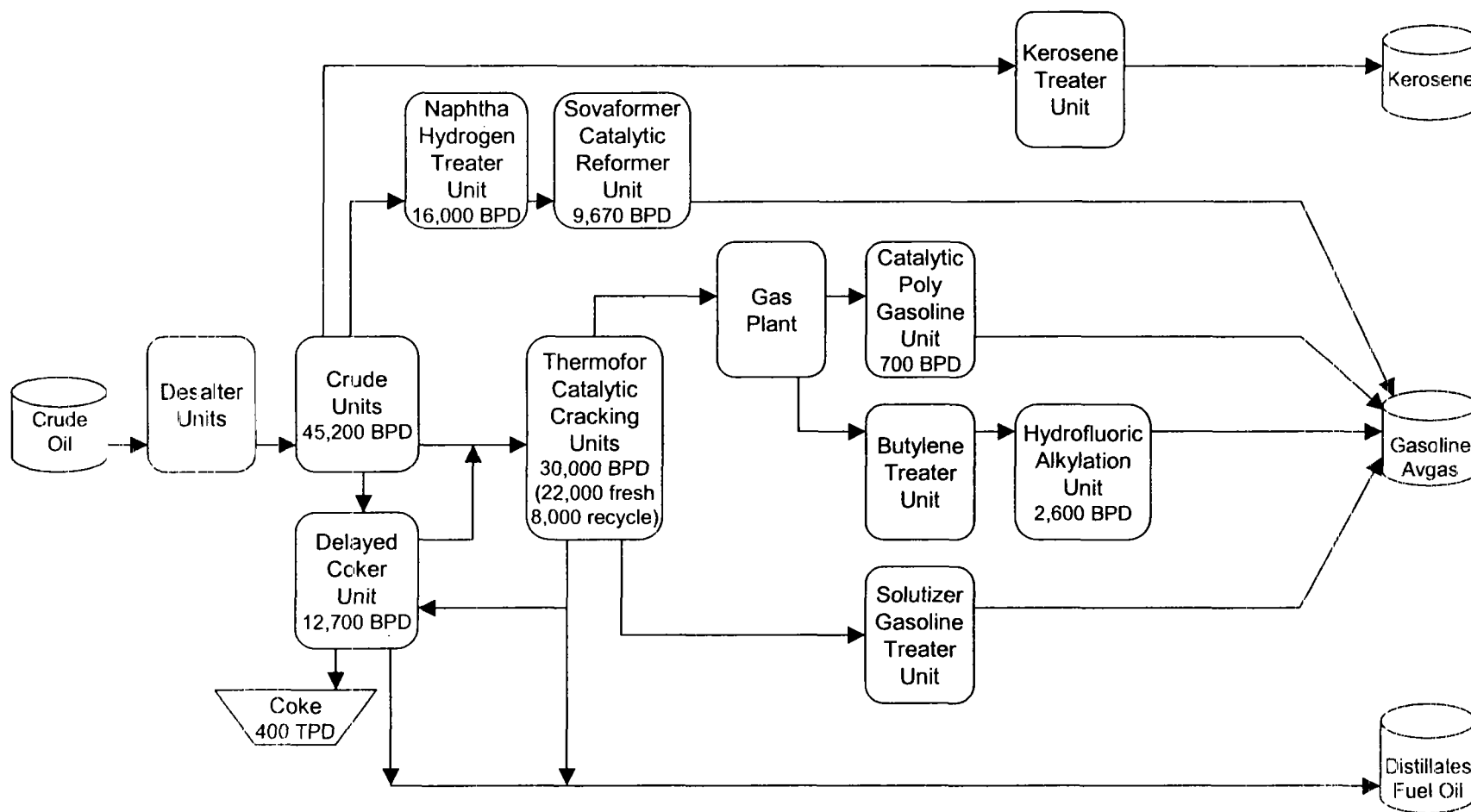
**ATTACHMENT V**  
**(Continued)**  
**ESTIMATED CONFIGURATION OF THE EAST ST. LOUIS REFINERY**  
**1950**



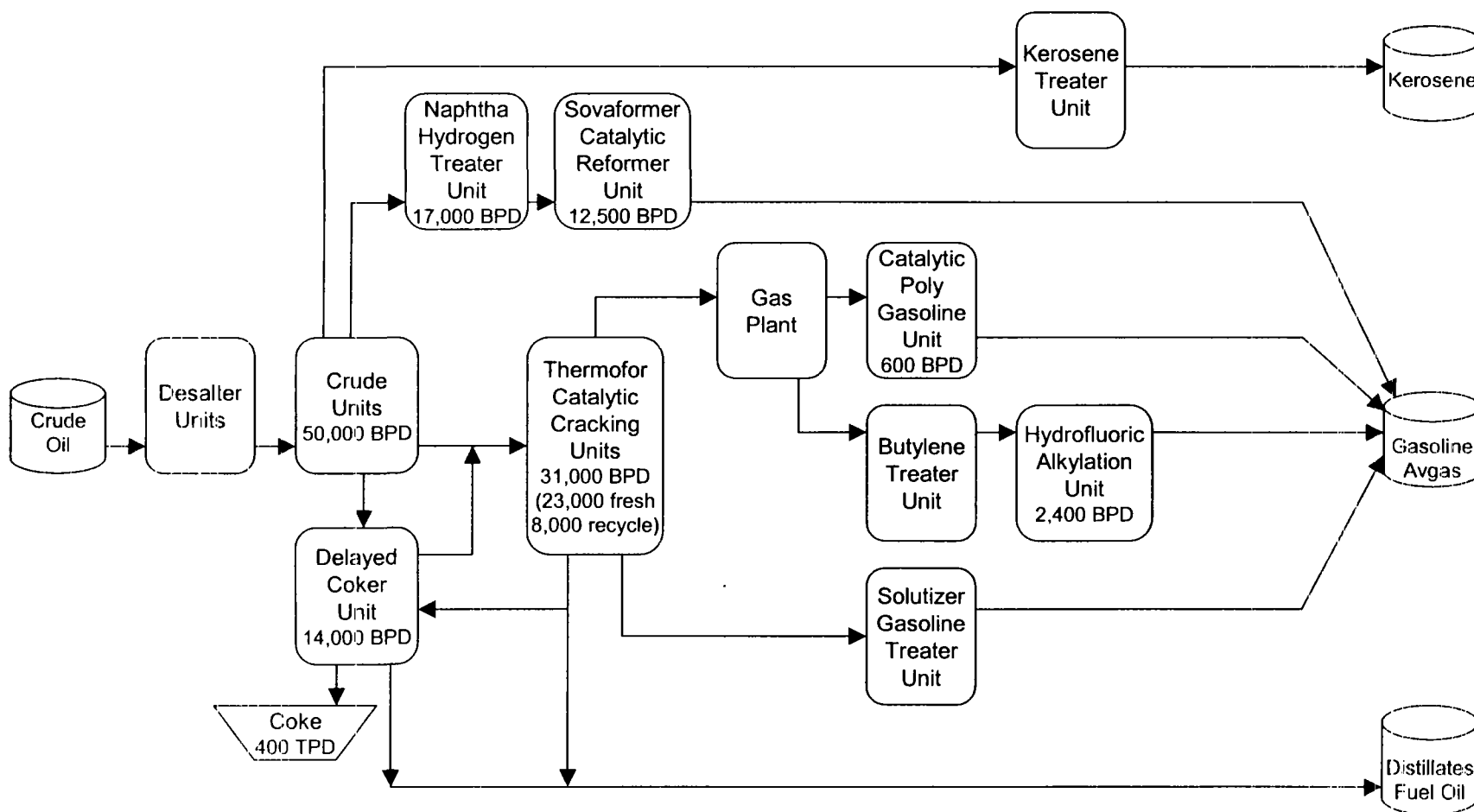
# ATTACHMENT V (Continued) ESTIMATED CONFIGURATION OF THE EAST ST. LOUIS REFINERY 1955



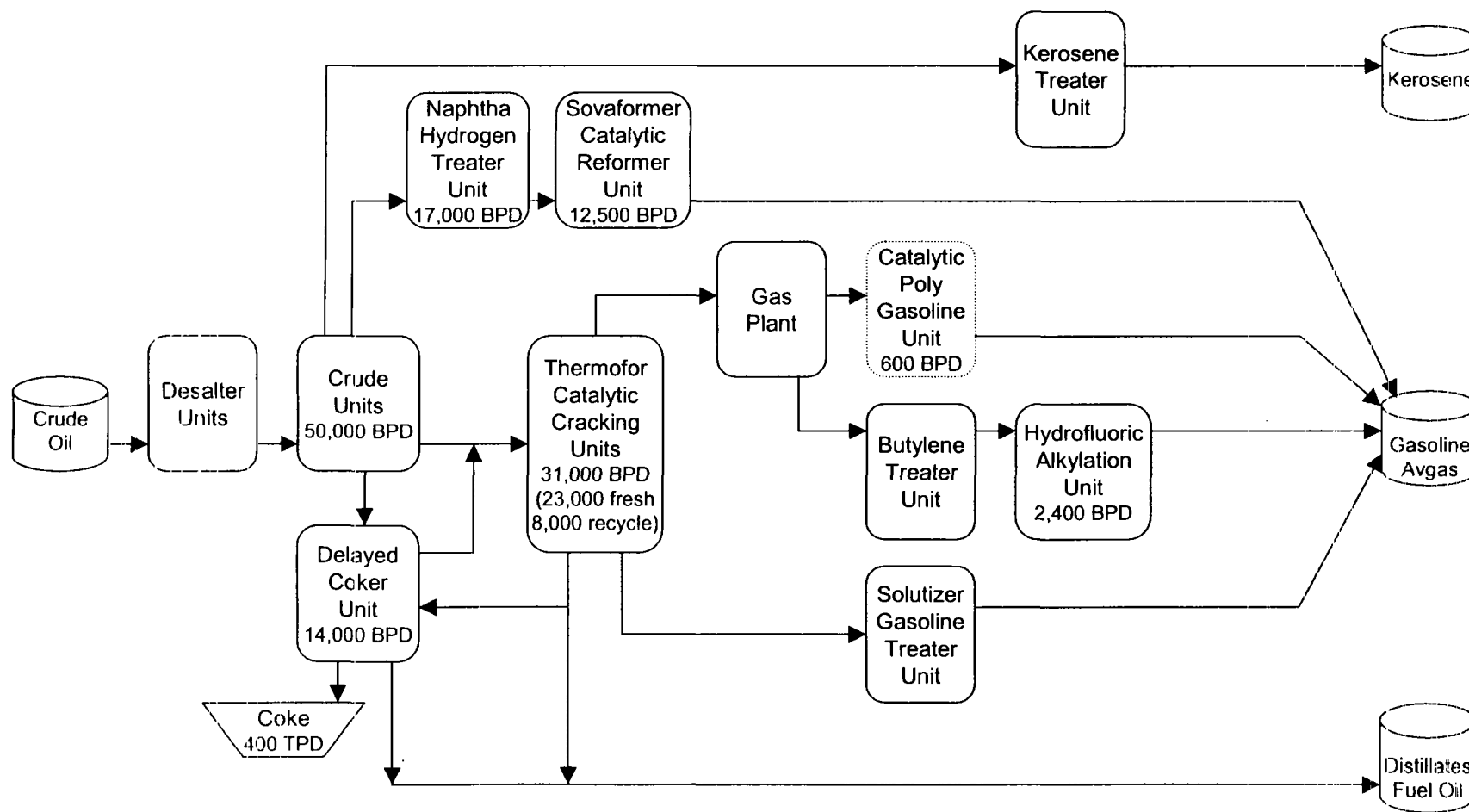
# **ATTACHMENT V** **(Continued)** **ESTIMATED CONFIGURATION OF THE EAST ST. LOUIS REFINERY** **1960**



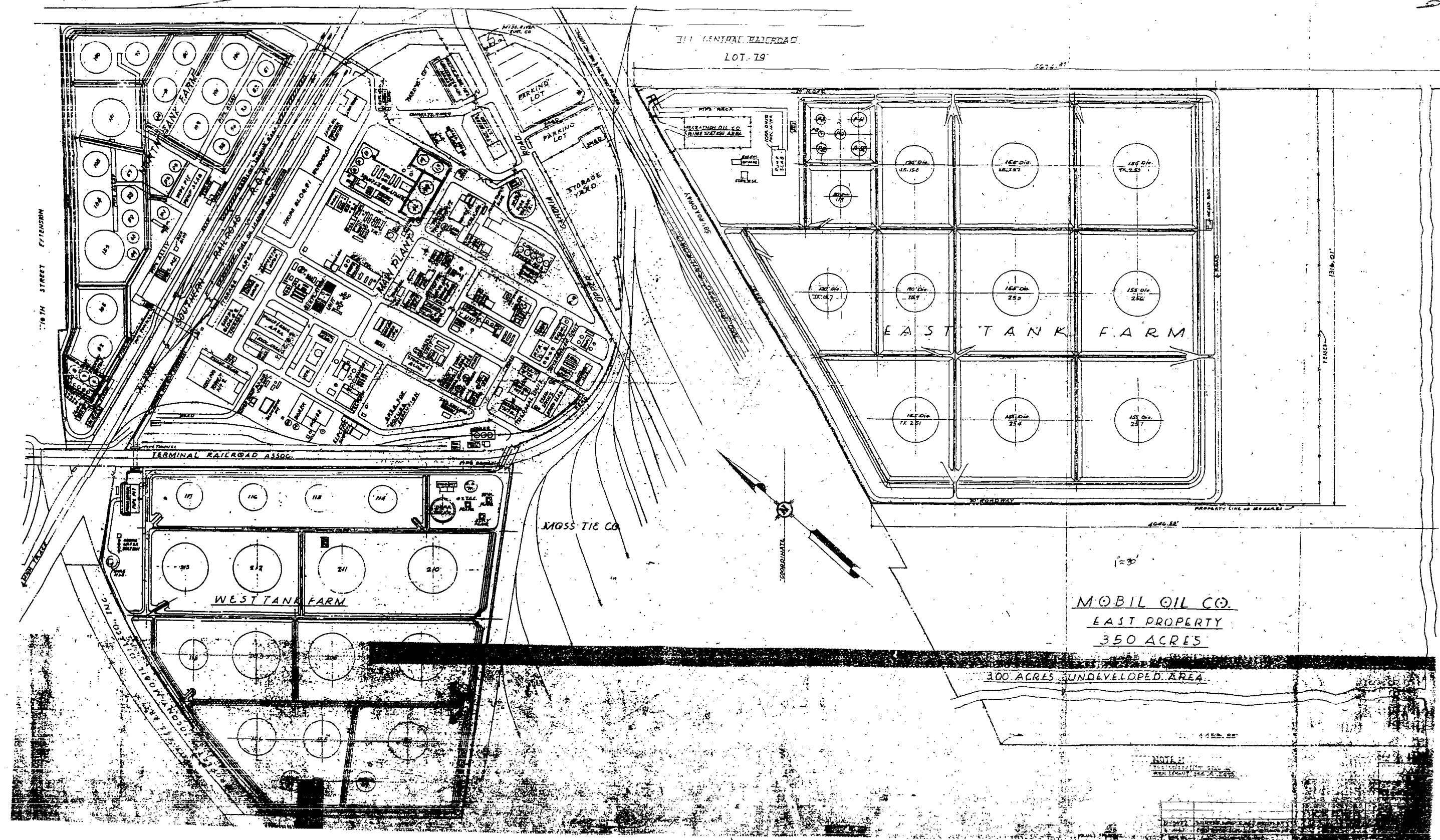
# ATTACHMENT V (Continued) ESTIMATED CONFIGURATION OF THE EAST ST. LOUIS REFINERY 1965



# **ATTACHMENT V** **(Continued)** **ESTIMATED CONFIGURATION OF THE EAST ST. LOUIS REFINERY** **1970**



# ATTACHMENT VI REFINERY PLOT PLAN



# ATTACHMENT VII-A

## DESCRIPTION OF EAST ST. LOUIS REFINERY SEWER SYSTEM

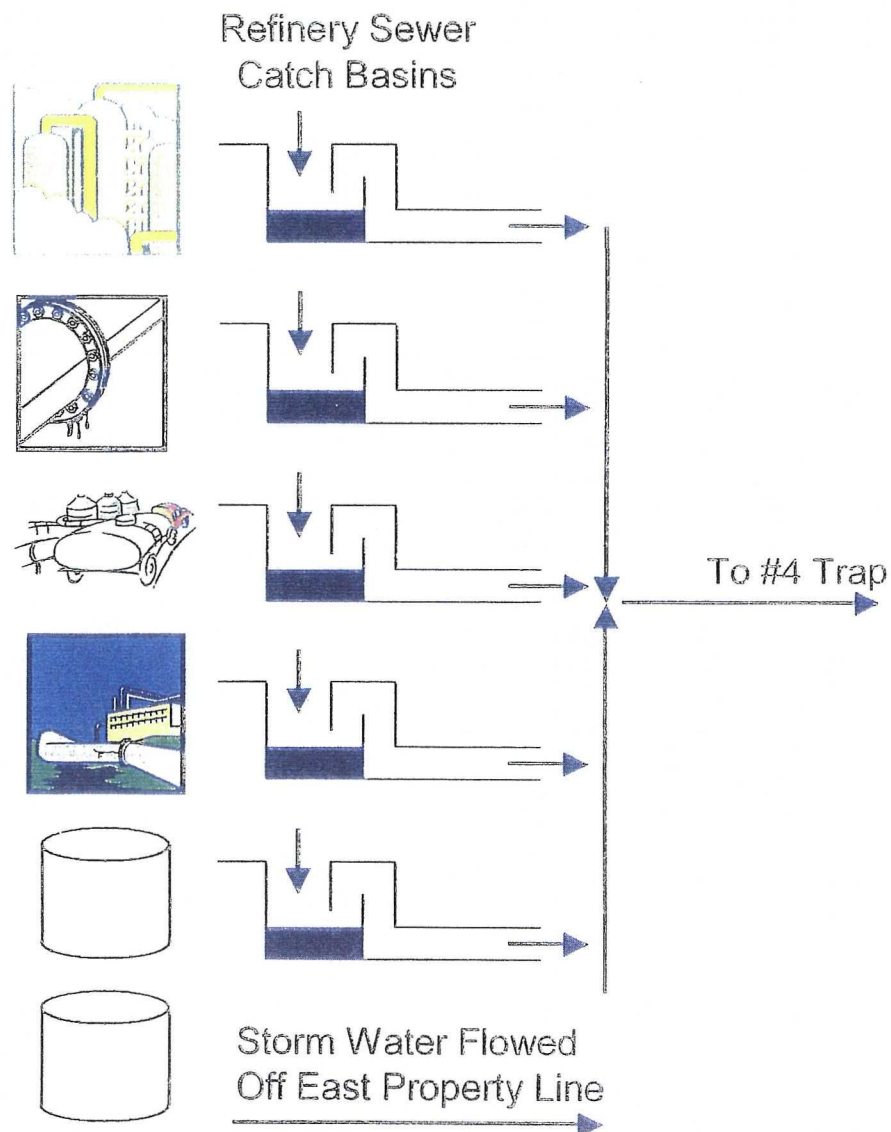
### Sources of Flow into Sewer

Process Equipment Draining  
 Unit Shutdown Draining  
 Cooling Tower Blowdown  
 Caustic Treating Solution Waste  
 Process Equipment Leaks  
 Process Area Wash Water  
 Coker Wash Water and Coke Fines  
 Steam Condensate  
 Truck and Rail Car Loading/Unloading  
 Draining Residual from Tankers  
 Spills from Overfilling  
 Loading Piping Draining

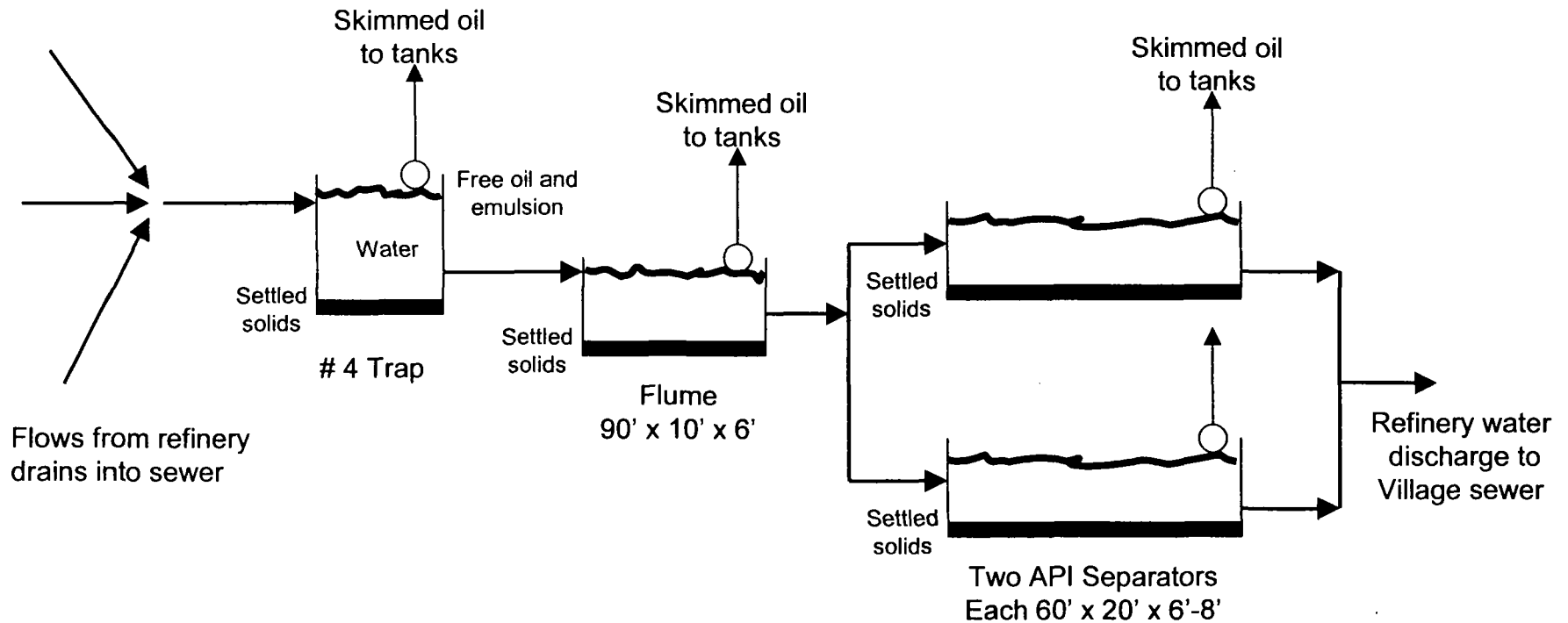
Piping Leaks

West Area Tank Bottom Drains  
 North Area Tank Bottom Drains  
 West and North Area Storm Water

East Area Tank Bottom Drains  
 East Area Storm Water



**ATTACHMENT VII-B**  
**DESCRIPTION OF EAST ST. LOUIS REFINERY**  
**SEWER OIL RECOVERY SYSTEM**  
**1951 ILLINOIS WATER POLLUTION INVESTIGATION**





## ATTACHMENT VIII

### EAST ST. LOUIS REFINERY WASTE WATER DISCHARGE

Drains operating areas, west and north tank areas. East tank area drains separately.

1918 – 1933      Discharge into ditches which flowed into Dead Creek

1933 – 1966      Discharge into Village of Monsanto sewer which has outfall into Mississippi River

1966 – 1970      Discharge into Village of Monsanto sewer which fed Village water treatment plant

Documented waste water discharge – process water only, no storm water in flow rates			
Period	Normal Rate (Gal./Min.)	Peak Rate (Gal./Min.)	Comments
~1940	400 – 700	1,500	
~1945	800 - 1,000	2,500 - 3,000	
1947	800	NA	
1951	520 – 660	NA	300 ppm solids, 250 ppm oil
1963	1,500 – 2,000		

# ATTACHMENT IX

## IDENTIFIED HAZARDOUS SUBSTANCES

### MOBIL / SOCONY - VACUUM / LUBERITE REFINERY

This is a list of the substances designated as hazardous under CERCLA, which are most likely generated and contained in the waste disposed by the East St. Louis refinery. The corresponding Chemical Abstract Service Registration Number (CASRN) or the hazardous substance category number is provided.

#### ***Metals***

Chromium	7440-47-3
Cobalt	7440-48-4
Lead	7439-92-1
Molybdenum Trioxide	1313-27-5
Nickel	7440-02-0
Vanadium	7440-62-1

#### ***Aromatic Hydrocarbons***

Benzene	71-43-2
Toluene	108-88-3
Xylene (Mixed Isomers)	1330-20-7

#### ***Polynuclear Aromatic Hydrocarbons***

Acenaphthene	83-32-9
Acenaphthylene	208-96-8
Anthracene	120-12-7
Benzo (a) Anthracene	K-170
Benzo (a) Pyrene	K-170
Benzo (b) Fluoranthene	205-99-2
Chrysene	218-01-9
Fluoranthene	206-44-0
Fluorene	86-76-7
Indeno (1,2,3-cd) Pyrene	193-39-5
Naphthalene	91-20-3
Phenanthrene	85-01-8
Pyrene	107-19-7

#### ***Phenols***

Phenol	108-95-2
Cresol (Mixed Isomers)	1319-77-3

#### ***Listed Hazardous Wastes for Petroleum Refineries***

Petroleum Refining Sludge from	F037
Primary Oil/Water/Solids Separation	
Slop Oil Emulsion Solids	K049
Heat Exchanger Bundle Cleaning	K050
Sludge	
API Separator Sludge	K051
Leaded Tank Bottoms	K052
Crude Oil Storage Tank Sediment	K169
Clarified Slurry Oil Storage Tank	K170
Sediment	
Spent Hydrotreating Catalyst	K171

## ATTACHMENT X

### CALCULATION OF ESTIMATED PROCESS SLUDGE AT THE EAST ST. LOUIS REFINERY

Based on article "Solids Waste Disposal", Oil and Gas Journal, March 3, 1958.

"Solids Waste Disposal" presented as a paper at the Second Waste Disposal Conference of the Western Petroleum Refiners Association on October 2-3, 1957.

Process sludge generation based on a comparison to Humble Baytown Refinery in 1957

A sludge production factor was derived by dividing Humble sludge pounds by the Humble refinery crude rate.

Excludes Humble lube treating sludge since East St. Louis stopped lube production in 1923.

Excludes Humble boiler treating water sludge since East St. Louis used well water instead of bay water.

	<u>lbs/day</u>	<u>lbs/bbl</u>	<u>Sludge Composition</u>		
			<u>% oil</u>	<u>% solids</u>	<u>% water</u>
Humble process sludge generation					
Acid/alkaline waste stream treating sludge	29,000	0.103	24	58	19
Slop oil emulsion treating sludge	26,500	0.094	29	49	22
API Separator sediment sludge - 1957	4,000	0.014	29	49	22
API Separator sediment sludge - 1947	10,000	0.050	29	49	22
Total	59,500 - 65,500				
Humble crude oil rate, barrels per day 1957	282,000				
Humble crude oil rate, barrels per day 1947	200,000				
Approximate densities of sludge components			oil <u>lb/cu ft</u> 40-50	solids <u>lb/cu ft</u> 35-60	water <u>lb/cu ft</u> 62

# ATTACHMENT X

(Continued)

## EAST ST. LOUIS ESTIMATED PROCESS SLUDGE GENERATION

### 1. Acid/alkaline waste stream treating sludge

Year	Crude bbls/day	Sludge pounds/bbl	Sludge pounds	cu. yd. @ 60 lbs/cu. ft.
1918	650	0.103	24,398	15
1919	850	0.103	31,905	20
1920	1,000	0.103	37,535	23
1921	1,000	0.103	37,535	23
1922	1,000	0.103	37,535	23
1923	2,000	0.103	75,071	46
1924	3,000	0.103	112,606	70
1925	3,000	0.103	112,606	70
1926	3,000	0.103	112,606	70
1927	4,000	0.103	150,142	93
1928	4,000	0.103	150,142	93
1929	4,000	0.103	150,142	93
1930	4,000	0.103	150,142	93
1931	3,500	0.103	131,374	81
1932	3,500	0.103	131,374	81
1933	3,500	0.103	131,374	81
1934	4,750	0.103	178,293	110
1935	4,750	0.103	178,293	110
1936	5,000	0.103	187,677	116
1937	6,000	0.103	225,213	139
1938	7,200	0.103	270,255	167
1939	7,000	0.103	262,748	162
1940	7,000	0.103	262,748	162
1941	16,000	0.103	600,567	371
1942	16,000	0.103	600,567	371
1943	16,000	0.103	600,567	371
1944	18,000	0.103	675,638	417
1945	20,000	0.103	750,709	463
1946	20,000	0.103	750,709	463
1947	21,000	0.103	788,245	487
1948	20,000	0.103	750,709	463
1949	22,700	0.103	852,055	526
1950	30,000	0.103	1,126,064	695
1951	30,000	0.103	1,126,064	695
1952	30,000	0.103	1,126,064	695
1953	40,000	0.103	1,501,418	927
1954	42,180	0.103	1,583,246	977
1955	42,200	0.103	1,583,996	978
1956	40,000	0.103	1,501,418	927
1957	40,000	0.103	1,501,418	927
1958	40,000	0.103	1,501,418	927
1959	45,200	0.103	1,696,603	1,047
1960	45,200	0.103	1,696,603	1,047
1961	50,000	0.103	1,876,773	1,159
1962	50,000	0.103	1,876,773	1,159
1963	50,000	0.103	1,876,773	1,159
1964	50,000	0.103	1,876,773	1,159
1965	50,000	0.103	1,876,773	1,159
1966	50,000	0.103	1,876,773	1,159
1967	50,000	0.103	1,876,773	1,159
1968	50,000	0.103	1,876,773	1,159
1969	50,000	0.103	1,876,773	1,159
1970	50,000	0.103	1,876,773	1,159
<b>Total Sludge</b>			<b>44,223,529</b>	<b>27,000</b>

# ATTACHMENT X

(Continued)

## EAST ST. LOUIS ESTIMATED PROCESS SLUDGE GENERATION

### 2. Slop oil emulsion treating sludge

Year	Crude bbls/day	Sludge pounds/bbl	Sludge pounds	cu. yd. @ 60 lbs/cu. ft.
1918	650	0.094	22,295	14
1919	850	0.094	29,155	18
1920	1,000	0.094	34,300	21
1921	1,000	0.094	34,300	21
1922	1,000	0.094	34,300	21
1923	2,000	0.094	68,599	42
1924	3,000	0.094	102,899	64
1925	3,000	0.094	102,899	64
1926	3,000	0.094	102,899	64
1927	4,000	0.094	137,199	85
1928	4,000	0.094	137,199	85
1929	4,000	0.094	137,199	85
1930	4,000	0.094	137,199	85
1931	3,500	0.094	120,049	74
1932	3,500	0.094	120,049	74
1933	3,500	0.094	120,049	74
1934	4,750	0.094	162,923	101
1935	4,750	0.094	162,923	101
1936	5,000	0.094	171,498	106
1937	6,000	0.094	205,798	127
1938	7,200	0.094	246,957	152
1939	7,000	0.094	240,098	148
1940	7,000	0.094	240,098	148
1941	16,000	0.094	548,794	339
1942	16,000	0.094	548,794	339
1943	16,000	0.094	548,794	339
1944	18,000	0.094	617,394	381
1945	20,000	0.094	685,993	423
1946	20,000	0.094	685,993	423
1947	21,000	0.094	720,293	445
1948	20,000	0.094	685,993	423
1949	22,700	0.094	778,602	481
1950	30,000	0.094	1,028,989	635
1951	30,000	0.094	1,028,989	635
1952	30,000	0.094	1,028,989	635
1953	40,000	0.094	1,371,986	847
1954	42,180	0.094	1,446,759	893
1955	42,200	0.094	1,447,445	893
1956	40,000	0.094	1,371,986	847
1957	40,000	0.094	1,371,986	847
1958	40,000	0.094	1,371,986	847
1959	45,200	0.094	1,550,344	957
1960	45,200	0.094	1,550,344	957
1961	50,000	0.094	1,714,982	1,059
1962	50,000	0.094	1,714,982	1,059
1963	50,000	0.094	1,714,982	1,059
1964	50,000	0.094	1,714,982	1,059
1965	50,000	0.094	1,714,982	1,059
1966	50,000	0.094	1,714,982	1,059
1967	50,000	0.094	1,714,982	1,059
1968	50,000	0.094	1,714,982	1,059
1969	50,000	0.094	1,714,982	1,059
1970	50,000	0.094	1,714,982	1,059
<b>Total Sludge</b>			<b>40,411,156</b>	<b>25,000</b>

# ATTACHMENT X

(Continued)

## EAST ST. LOUIS ESTIMATED PROCESS SLUDGE GENERATION

### 3. API Separator sediment sludge

Year	Crude bbls/day	Sludge 1957 rate pounds/bbl	Sludge 1957 rate pounds	Sludge 1957 rate cu. yd. @ 60 lbs/cu. ft.	Sludge 1947 rate pounds/bbl	Sludge 1947 rate pounds	Sludge 1947 rate cu. yd. @ 60 lbs/cu. ft.
1918	650	0.014	3,365	2	0.050	11,863	7
1919	850	0.014	4,401	3	0.050	15,513	10
1920	1,000	0.014	5,177	3	0.050	18,250	11
1921	1,000	0.014	5,177	3	0.050	18,250	11
1922	1,000	0.014	5,177	3	0.050	18,250	11
1923	2,000	0.014	10,355	6	0.050	36,500	23
1924	3,000	0.014	15,532	10	0.050	54,750	34
1925	3,000	0.014	15,532	10	0.050	54,750	34
1926	3,000	0.014	15,532	10	0.050	54,750	34
1927	4,000	0.014	20,709	13	0.050	73,000	45
1928	4,000	0.014	20,709	13	0.050	73,000	45
1929	4,000	0.014	20,709	13	0.050	73,000	45
1930	4,000	0.014	20,709	13	0.050	73,000	45
1931	3,500	0.014	18,121	11	0.050	63,875	39
1932	3,500	0.014	18,121	11	0.050	63,875	39
1933	3,500	0.014	18,121	11	0.050	63,875	39
1934	4,750	0.014	24,592	15	0.050	86,688	54
1935	4,750	0.014	24,592	15	0.050	86,688	54
1936	5,000	0.014	25,887	16	0.050	91,250	56
1937	6,000	0.014	31,064	19	0.050	109,500	68
1938	7,200	0.014	37,277	23	0.050	131,400	81
1939	7,000	0.014	36,241	22	0.050	127,750	79
1940	7,000	0.014	36,241	22	0.050	127,750	79
1941	16,000	0.014	82,837	51	0.050	292,000	180
1942	16,000	0.014	82,837	51	0.050	292,000	180
1943	16,000	0.014	82,837	51	0.050	292,000	180
1944	18,000	0.014	93,191	58	0.050	328,500	203
1945	20,000	0.014	103,546	64	0.050	365,000	225
1946	20,000	0.014	103,546	64	0.050	365,000	225
1947	21,000	0.014	108,723	67	0.050	383,250	237
1948	20,000	0.014	103,546	64	0.050	365,000	225
1949	22,700	0.014	117,525	73	0.050	414,275	256
1950	30,000	0.014	155,319	96	0.050	547,500	338
1951	30,000	0.014	155,319	96	0.050	547,500	338
1952	30,000	0.014	155,319	96	0.050	547,500	338
1953	40,000	0.014	207,092	128	0.050	730,000	451
1954	42,180	0.014	218,379	135	0.050	769,785	475
1955	42,200	0.014	218,482	135	0.050	770,150	475
1956	40,000	0.014	207,092	128	0.050	730,000	451
1957	40,000	0.014	207,092	128	0.050	730,000	451
1958	40,000	0.014	207,092	128	0.050	730,000	451
1959	45,200	0.014	234,014	144	0.050	824,900	509
1960	45,200	0.014	234,014	144	0.050	824,900	509
1961	50,000	0.014	258,865	160	0.050	912,500	563
1962	50,000	0.014	258,865	160	0.050	912,500	563
1963	50,000	0.014	258,865	160	0.050	912,500	563
1964	50,000	0.014	258,865	160	0.050	912,500	563
1965	50,000	0.014	258,865	160	0.050	912,500	563
1966	50,000	0.014	258,865	160	0.050	912,500	563
1967	50,000	0.014	258,865	160	0.050	912,500	563
1968	50,000	0.014	258,865	160	0.050	912,500	563
1969	50,000	0.014	258,865	160	0.050	912,500	563
1970	50,000	0.014	258,865	160	0.050	912,500	563
Total Sludge			6,099,797	4,000		21,501,785	13,000

## ATTACHMENT X

(Continued)

### CALCULATION OF TCC CATALYST WASTE

#### Waste catalyst fines produced from the attrition of whole catalyst

Period	TCC rate bbls/day	Years number	Catalyst	Waste	Metal content on catalyst fines			
			Loss pounds/bbl	Catalyst pounds	Nickel ppm	Vanadium ppm	Nickel pounds	Vanadium pounds
1944-1954	16,000	10	0.1	5,840,000	60	120	350	701
1954-1959	29,100	5	0.1	5,310,750	60	120	319	637
1959-1965	30,000	6	0.1	6,570,000	60	120	394	788
1965-1970	31,000	5	0.1	5,657,500	60	120	339	679
Total pounds of catalyst waste				23,378,250			1,400	2,800
Total cubic yards of catalyst				14,000				

#### Waste whole bead catalyst produced from the economical replacement of catalyst

Period	TCC rate bbls/day	Years number	Catalyst	Waste	Metal content on equilibrium catalyst			
			Make-up pounds/bbl	Catalyst pounds	Nickel ppm	Vanadium ppm	Nickel pounds	Vanadium pounds
1944-1954	16,000	10	0.4	23,360,000	20	40	467	934
1954-1959	29,100	5	0.4	21,243,000	20	40	425	850
1959-1965	30,000	6	0.4	26,280,000	20	40	526	1,051
1965-1970	31,000	5	0.4	22,630,000	20	40	453	905
Total pounds of catalyst waste				93,513,000			1,900	3,700
Total cubic yards of catalyst				58,000				

#### Disposition of catalyst wastes

Most TCC catalyst fines are captured as dry fines in regenerator flue gas cyclone  
Some TCC catalyst fines are captured as oil wet fines in TCC slurry bottoms product tank bottoms  
Whole TCC catalyst beads are captured as equilibrium catalyst and replaced with fresh catalyst

#### Source for catalyst waste rates and catalyst metals loadings for Mid-Continent crudes:

"Distribution of metal contaminants on cracking catalysts", Paper presented at American Chemical Society, Division of Petroleum Chemistry, Dallas Meeting, April 8-13, 1956  
"Earnings - a function of catalyst activity", The Petroleum Engineer, August, 1946  
"Catalytic Cracking in Airlift TCC Units", The Petroleum Engineer, August, 1952  
"Recent Developments in TCC Cracking", Proceeding Fourth World Petroleum Congress-Section III/E, Presented by J.W. Wayne (Socony-Mobil), June 7, 1955

## ATTACHMENT X

(Continued)

### CALCULATION OF TANK BOTTOM SLUDGE FROM TANK CLEANING

#### SUMMARY OF TANK BOTTOM SLUDGE CALCULATIONS

	Crude Oil	Gasoline	Distillate	Slurry
	<u>Cubic Yards</u>	<u>Cubic Yards</u>	<u>Cubic Yards</u>	<u>Cubic Yards</u>
1920's	800	1,000	1,000	200
1930's	800	1,000	1,000	200
1940's	1,400	1,700	1,400	300
1950's	2,000	2,400	1,800	400
1960's	2,000	2,400	1,800	400
Total	7,000	8,500	7,000	1,500

#### Basis:

Crude, gasoline, and distillate tanks cleaned once every ten years.

TCC Slurry cleaned once every five years.

Intermediates assumed to not be cleaned due to constant turnover.

Crude, distillate, and slurry tank sludge depth of six inches.

Gasoline tank sludge depth of three inches.

Tank service allocated according to 20% crude, 7% intermediates, 49% gasoline, 20% distillates, 4% slurry.

Tank service based on inventories reported for 1939 and 1950 by Socony Mobil

Tank diameters estimated from refinery plot plan drawing.

Volume of sludge removed each cleaning determined using tank bottom area and sludge height.

The years of existence for individual tanks determined from aerial photographs.

Tanks existing in 1940 used for the decades of the 1920's and 1930's estimates.

Tanks existing in 1950 used for the decades of the 1950's and 1960's estimates.

Average of tanks existing in 1940 and 1950 used for the decade of the 1940's estimate.

Details of tanks on the following page.



# ATTACHMENT X

(Continued)

## CALCULATION OF TANK BOTTOM SLUDGE VOLUMES

Tank Field	Tank Number	External Floating Roof?	Photo Apprais Date	Plot Plan Diameter (Feet)	Area (Sq Ft)	Ext'd Height (Feet)	Estimated Capacity (Barrels)	Depth Inches	Number of Cleanings in 10 yrs	Volume Cubic Yard	Product C I G D S	1940 Crude	1940 Interm.	1940 Gasoline	1940 Distillate	1940 Slurry	Product C I G D S	1950 Crude	1950 Interm.	1950 Gasoline	1950 Distillate	1950 Slurry		
East	119	Float	1950	80	5,026	30	26,855	3	1	47							G				47			
East	151		1950	120	11,309	30	60,425	6	1	209							D					209		
East	158		1950	120	11,309	30	60,425	6	1	209							D					209		
East	159		1950	120	11,309	30	60,425	6	1	209							D					209		
East	251		1950	155	18,869	30	100,812	6	1	349							D					349		
East	252		1950	155	18,869	30	100,812	3	1	175							G				175			
East	253		Float	1950	155	18,869	30	100,812	3	1	175							G				175		
East	254		Float	1950	155	18,869	30	100,812	3	1	175							G				175		
East	255		Float	1950	155	18,869	30	100,812	3	1	175							G				175		
East	256		Float	1950	155	18,869	30	100,812	3	1	175							G				175		
East	257	Float	1950	155	18,869	30	100,812	3	1	175							G				175			
Total East							913,816			2,073														
West	82	Float	1940	80	2,827	30	15,106	6	1	52	D					52	I			52				
West	83		1950	80	2,827	30	15,106	6	1	52							I			52				
West	114		1940	100	7,854	30	41,961	6	1	145	I		145				I			145				
West	115		1940	100	7,854	30	41,961	6	1	145	I		145				I			145				
West	116		1950	100	7,854	30	41,961	6	1	145							I			145				
West	117		1950	100	7,854	30	41,961	6	1	145							I			145				
West	118		1950	100	7,854	30	41,961	6	1	145							I			145				
West	154		1940	120	11,309	30	60,425	6	1	209		D					209	D				209		
West	155		1940	120	11,309	30	60,425	6	1	209		D					209	D				209		
West	156		1950	120	11,309	30	60,425	6	1	209								D				209		
West	207	Float	1940	165	21,382	30	114,240	3	1	198	G			198			G				198			
West	208	Float	1940	165	21,382	30	114,240	3	1	198	G			198			G				198			
West	209	Float	1950	165	21,382	30	114,240	6	1	396	C						C		396					
West	210	Float	1940	165	21,382	30	114,240	6	1	396	C		396				C		396					
West	211		1940	165	21,382	30	114,240	6	1	396	C		396				C		396					
West	212		1940	165	21,382	30	114,240	6	1	396	D					396	C		396					
West	213		1950	165	21,382	30	114,240	6	1	396							C		396					
Total West							799,681			2,376														
North	48	Float	1940	45	1,590	30	8,497	3	1	15	G			15			G				15			
North	49		1940	45	1,590	30	8,497	3	1	15	G			15			G				15			
North	51		1940	60	2,827	30	15,106	3	1	26	G			26			G				26			
North	52		1940	60	2,827	30	15,106	3	1	26	G			26			G				26			
North	53		1940	60	2,827	30	15,106	3	1	26	G			26			G				26			
North	54		1940	60	2,827	30	15,106	3	1	26	G			26			G				26			
North	55		1940	60	2,827	30	15,106	3	1	26	G			26			G				26			
North	57		1940	80	2,827	30	15,106	3	1	26	G			26			G				26			
North	58		1940	80	2,827	30	15,106	3	1	26	G			26			G				26			
North	59		1940	60	2,827	30	15,106	3	1	26	G			26			G				26			
North	79	1950	80	5,026	30	26,855	6	2	186								S					186		
North	80	Float	1940	80	5,026	30	26,855	6	2	186	S					186	S					186		
North	81	Float	1950	80	5,026	30	26,855	6	1	93							D				93			
North	82	Float	1940	80	5,026	30	26,855	6	1	93	D					93	D				93			
North	100	Float	1940	90	6,362	30	33,989	3	1	59	G			59			G				59			
North	101	Float	1940	90	6,362	30	33,989	3	1	59	G			59			G				59			
North	102	Float	1950	90	6,362	30	33,989	3	1	59							G				59			
North	103	1950	90	6,362	30	33,989	3	1	59								G				59			
North	104	1950	90	6,362	30	33,989	3	1	59								G				59			
North	105	1950	90	6,362	30	33,989	3	1	59								G				59			
North	150	1950	110	9,503	30	50,773	3	1	88								G				88			
North	151	1940	130	13,273	30	70,915	3	1	123	G				123			G				123			
North	153	1940	140	15,393	30	82,244	3	1	143	G				143			G				143			
Total North							653,130			1,504														
Grand Total							2,366,627			5,952				792	291	1,018	980	188	1,988	832	2,436	1,792	372	
												% sludge	24%	5%	31%	30%	0%			27%	11%	33%	24%	5%
												% tank area	13%	7%	48%	23%	4%			20%	6%	49%	16%	4%

## ATTACHMENT X

(Continued)

### CALCULATION OF OIL AND SOLIDS IN WASTE WATER DISCHARGE

#### Reported waste water discharge rates

	1951 Illinois Pollution Survey	1951 Illinois Pollution Survey	1944 Letter From Socony-Vacuum Pre- WW II Rates	1944 Letter From Socony-Vacuum Current Rates
	<u>GPD</u>	<u>GPD</u>	<u>GPM</u>	<u>GPM</u>
Washings	400,000	278		
Process	200,000	139		
Seals	150,000	104		
Total - Normal	750,000	521	400-700	800-1,200
Total - Peak			1,500	2,500-3,000

#### Discharge quality

	<u>GPM</u>	<u>GPD</u>	<u>C.Y./yr</u>	<u>BBL/yr</u>
Oil - 250 ppm	0.13	188	338	1,629
Solids - 300 ppm	0.16	225	406	

#### Order of magnitude estimate of solids and oil in waste water for 1918-1970

Average crude rate for operating history =	23,000 BPD
Crude rate in 1951 =	30,000 BPD
Ratio of average crude rate to 1951 crude rate =	0.77
Number of operating years =	52

#### Volumes at 521 GPM waste water rate

	<u>Cubic yards</u>	<u>Barrels</u>
Oil	13,000	65,000
Solids	16,000	

#### Volumes at 1,200 GPM waste water rate

	<u>Cubic yards</u>	<u>Barrels</u>
Oil	30,000	150,000
Solids	37,000	

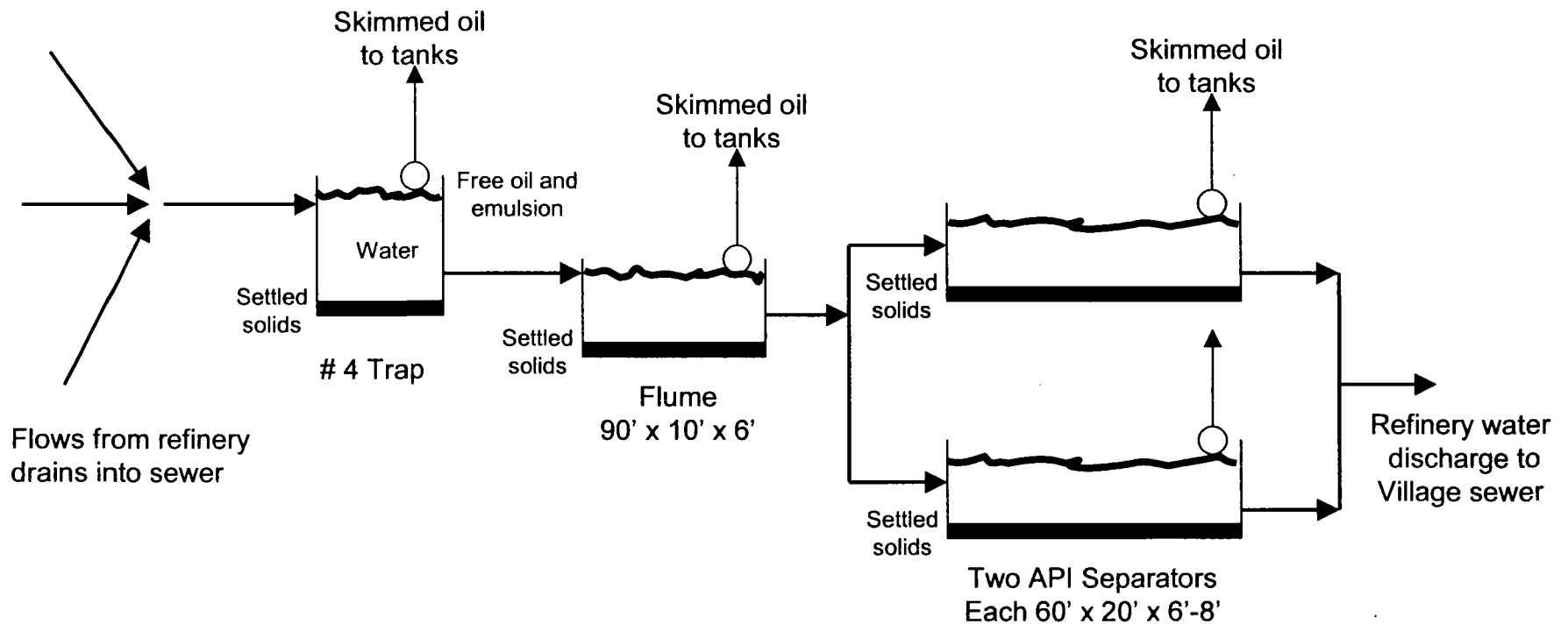
# ATTACHMENT X

(Continued)

## INVENTORIES FROM SOCONY RECORDS

<u>3/31/1939</u>	<u>Barrels</u>	<u>Crude</u>	<u>Inter.</u>	<u>Gasoline</u>	<u>Distillate</u>
Ethyl	22,408			22,408	
Mobilgas	256,638			256,638	
Metro 67 octane	19,090			19,090	
Metro w.w.	4,120		4,120		
Kerosene	7,651				7,651
Mobil heat	61,676				61,676
#7 fuel	56,262				56,262
Treated gasoline	9,845		9,845		
Burner oil	1,129				1,129
#5 fuel	9,003				9,003
Crude oil	89,794	89,794			
Untreated kerosene	1,048		1,048		
Coke plant gas oil	21,166		21,166		
Process oil	4,307		4,307		
Absorber oil	34		34		
Slop	6,018		6,018		
Untreated gasoline	491		491		
<b>Totals, Barrels</b>	<b>570,679</b>	<b>89,794</b>	<b>47,028</b>	<b>298,136</b>	<b>135,722</b>
<b>Percentages</b>	<b>100%</b>	<b>16%</b>	<b>8%</b>	<b>52%</b>	<b>24%</b>
<u>1/1/1950</u>	<u>Barrels</u>	<u>Crude</u>	<u>Inter.</u>	<u>Gasoline</u>	<u>Distillate</u>
Crude oil	230,783	230,783			
Mobilgas special	117,895			117,895	
Mobilgas special	279,102			279,102	
Metro	1,071			1,071	
Mobilgas special stock	13,192			13,192	
Mobilgas stock	33,977			33,977	
Untreated motor gasoline	11,162			11,162	
Treated stab. B-B stock	2,344		2,344		
Kerosene	33,912				33,912
#1 fuel	8,315				8,315
Untreated kerosene	730		730		
#2 fuel	74,617				74,617
Mobilheat	214				214
Raw cresylic acid	140		140		
Gas oil	11,413		11,413		
Process oil	6,552		6,552		
Slop oil	1,887		1,887		
#6 fuel (L.S.)	62,379				62,379
#6 fuel (H.S.)	41,485				41,485
<b>Totals, Barrels</b>	<b>931,170</b>	<b>230,783</b>	<b>23,066</b>	<b>456,399</b>	<b>220,922</b>
<b>Percentages</b>	<b>100%</b>	<b>25%</b>	<b>2%</b>	<b>49%</b>	<b>24%</b>

**ATTACHMENT VII-B**  
**DESCRIPTION OF EAST ST. LOUIS REFINERY**  
**SEWER OIL RECOVERY SYSTEM**  
**1951 ILLINOIS WATER POLLUTION INVESTIGATION**



## ATTACHMENT VIII

### EAST ST. LOUIS REFINERY WASTE WATER DISCHARGE

Drains operating areas, west and north tank areas. East tank area drains separately.

1918 – 1933      Discharge into ditches which flowed into Dead Creek

1933 – 1966      Discharge into Village of Monsanto sewer which has outfall into Mississippi River

1966 – 1970      Discharge into Village of Monsanto sewer which fed Village water treatment plant

Documented waste water discharge – process water only, no storm water in flow rates			
Period	Normal Rate (Gal./Min.)	Peak Rate (Gal./Min.)	Comments
~1940	400 – 700	1,500	
~1945	800 - 1,000	2,500 - 3,000	
1947	800	NA	
1951	520 – 660	NA	300 ppm solids, 250 ppm oil
1963	1,500 – 2,000		

# ATTACHMENT IX

## IDENTIFIED HAZARDOUS SUBSTANCES

### MOBIL / SOCONY - VACUUM / LUBERITE REFINERY

This is a list of the substances designated as hazardous under CERCLA, which are most likely generated and contained in the waste disposed by the East St. Louis refinery. The corresponding Chemical Abstract Service Registration Number (CASRN) or the hazardous substance category number is provided.

#### ***Metals***

Chromium	7440-47-3
Cobalt	7440-48-4
Lead	7439-92-1
Molybdenum Trioxide	1313-27-5
Nickel	7440-02-0
Vanadium	7440-62-1

#### ***Aromatic Hydrocarbons***

Benzene	71-43-2
Toluene	108-88-3
Xylene (Mixed Isomers)	1330-20-7

#### ***Polynuclear Aromatic Hydrocarbons***

Acenaphthene	83-32-9
Acenaphthylene	208-96-8
Anthracene	120-12-7
Benzo (a) Anthracene	K-170
Benzo (a) Pyrene	K-170
Benzo (b) Fluoranthene	205-99-2
Chrysene	218-01-9
Fluoranthene	206-44-0
Fluorene	86-76-7
Indeno (1,2,3-cd) Pyrene	193-39-5
Naphthalene	91-20-3
Phenanthrene	85-01-8
Pyrene	107-19-7

#### ***Phenols***

Phenol	108-95-2
Cresol (Mixed Isomers)	1319-77-3

#### ***Listed Hazardous Wastes for Petroleum Refineries***

Petroleum Refining Sludge from	F037
Primary Oil/Water/Solids Separation	
Slop Oil Emulsion Solids	K049
Heat Exchanger Bundle Cleaning	K050
Sludge	
API Separator Sludge	K051
Leaded Tank Bottoms	K052
Crude Oil Storage Tank Sediment	K169
Clarified Slurry Oil Storage Tank	K170
Sediment	
Spent Hydrotreating Catalyst	K171

## ATTACHMENT X

### CALCULATION OF ESTIMATED PROCESS SLUDGE AT THE EAST ST. LOUIS REFINERY

Based on article "Solids Waste Disposal", Oil and Gas Journal, March 3, 1958.

"Solids Waste Disposal" presented as a paper at the Second Waste Disposal Conference of the Western Petroleum Refiners Association on October 2-3, 1957.

Process sludge generation based on a comparison to Humble Baytown Refinery in 1957

A sludge production factor was derived by dividing Humble sludge pounds by the Humble refinery crude rate.

Excludes Humble lube treating sludge since East St. Louis stopped lube production in 1923.

Excludes Humble boiler treating water sludge since East St. Louis used well water instead of bay water.

	<u>lbs/day</u>	<u>lbs/bbl</u>	<u>Sludge Composition</u>		
			<u>% oil</u>	<u>% solids</u>	<u>% water</u>
Humble process sludge generation					
Acid/alkaline waste stream treating sludge	29,000	0.103	24	58	19
Slop oil emulsion treating sludge	26,500	0.094	29	49	22
API Separator sediment sludge - 1957	4,000	0.014	29	49	22
API Separator sediment sludge - 1947	10,000	0.050	29	49	22
Total	59,500 - 65,500				
Humble crude oil rate, barrels per day 1957	282,000				
Humble crude oil rate, barrels per day 1947	200,000				

	<u>oil</u>	<u>solids</u>	<u>water</u>
	<u>lb/cu ft</u>	<u>lb/cu ft</u>	<u>lb/cu ft</u>
Approximate densities of sludge components	40-50	35-60	62

# ATTACHMENT X

(Continued)

## EAST ST. LOUIS ESTIMATED PROCESS SLUDGE GENERATION

### 1. Acid/alkaline waste stream treating sludge

Year	Crude bbls/day	Sludge pounds/bbl	Sludge pounds	cu. yd. @ 60 lbs/cu. ft.
1918	650	0.103	24,398	15
1919	850	0.103	31,905	20
1920	1,000	0.103	37,535	23
1921	1,000	0.103	37,535	23
1922	1,000	0.103	37,535	23
1923	2,000	0.103	75,071	46
1924	3,000	0.103	112,606	70
1925	3,000	0.103	112,606	70
1926	3,000	0.103	112,606	70
1927	4,000	0.103	150,142	93
1928	4,000	0.103	150,142	93
1929	4,000	0.103	150,142	93
1930	4,000	0.103	150,142	93
1931	3,500	0.103	131,374	81
1932	3,500	0.103	131,374	81
1933	3,500	0.103	131,374	81
1934	4,750	0.103	178,293	110
1935	4,750	0.103	178,293	110
1936	5,000	0.103	187,677	116
1937	6,000	0.103	225,213	139
1938	7,200	0.103	270,255	167
1939	7,000	0.103	262,748	162
1940	7,000	0.103	262,748	162
1941	16,000	0.103	600,567	371
1942	16,000	0.103	600,567	371
1943	16,000	0.103	600,567	371
1944	18,000	0.103	675,638	417
1945	20,000	0.103	750,709	463
1946	20,000	0.103	750,709	463
1947	21,000	0.103	788,245	487
1948	20,000	0.103	750,709	463
1949	22,700	0.103	852,055	526
1950	30,000	0.103	1,126,064	695
1951	30,000	0.103	1,126,064	695
1952	30,000	0.103	1,126,064	695
1953	40,000	0.103	1,501,418	927
1954	42,180	0.103	1,583,246	977
1955	42,200	0.103	1,583,996	978
1956	40,000	0.103	1,501,418	927
1957	40,000	0.103	1,501,418	927
1958	40,000	0.103	1,501,418	927
1959	45,200	0.103	1,696,603	1,047
1960	45,200	0.103	1,696,603	1,047
1961	50,000	0.103	1,876,773	1,159
1962	50,000	0.103	1,876,773	1,159
1963	50,000	0.103	1,876,773	1,159
1964	50,000	0.103	1,876,773	1,159
1965	50,000	0.103	1,876,773	1,159
1966	50,000	0.103	1,876,773	1,159
1967	50,000	0.103	1,876,773	1,159
1968	50,000	0.103	1,876,773	1,159
1969	50,000	0.103	1,876,773	1,159
1970	50,000	0.103	1,876,773	1,159
<b>Total Sludge</b>			<b>44,223,529</b>	<b>27,000</b>